



CRYSIS 3

Shining the Light on Crysis 3

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Presenter

Name

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Title

Sr. Lighting Artist, Crytek

Games



Plan

Introduction

Production

Lighting basics

Physics & Materials

Real-Time Lighting Features

Case Studies

- Outdoor Lighting

- Indoor Lighting

- Cinematics

Conclusion

Introduction

Crytek

Founded in 1999

Core pillars

Technology (CryENGINE)

Content creation (Crysis, Ryse, Homefront 2, etc.)

Publishing (GFACE)

850 employees across 9 studios

Frankfurt (Germany)

Nottingham (UK)

Kiev (Ukraine)

Austin (USA)

Budapest (Hungary)

Seoul (South Korea)

Sofia (Bulgaria)

Shanghai (China)

Istanbul (Turkey)



CryENGINE

Development time

+13 years

Motto since CryENGINE 2

"Real-time all the time"

Platforms

PC & mobile

Microsoft Xbox 360 & Xbox One

Sony PS3 & PS4

Licensees

Games

Military (simulation & training)

Architecture (visualization)

Etc.



CRYENGINE® E

CryENGINE\Games and Licensees

Games

Ryse & Homefront 2 (Crytek)

Sniper Ghost Warrior 2 (City Interactive)

MechWarrior Online (Piranha Games)

Monster Hunter Online (Tencent, Capcom)

Star Citizen (Cloud Imperium Games Corporation)

Civilization Online (2K, XLGAMES)

Etc.

Serious games licensees

Enodo (Architecture)

RealTime Immersive (Military)

Thales Group (Military)

Lockheed Martin (Military)

Meggitt (Aerospace)

Etc.

Crysis Franchise

Type

First Person Shooter

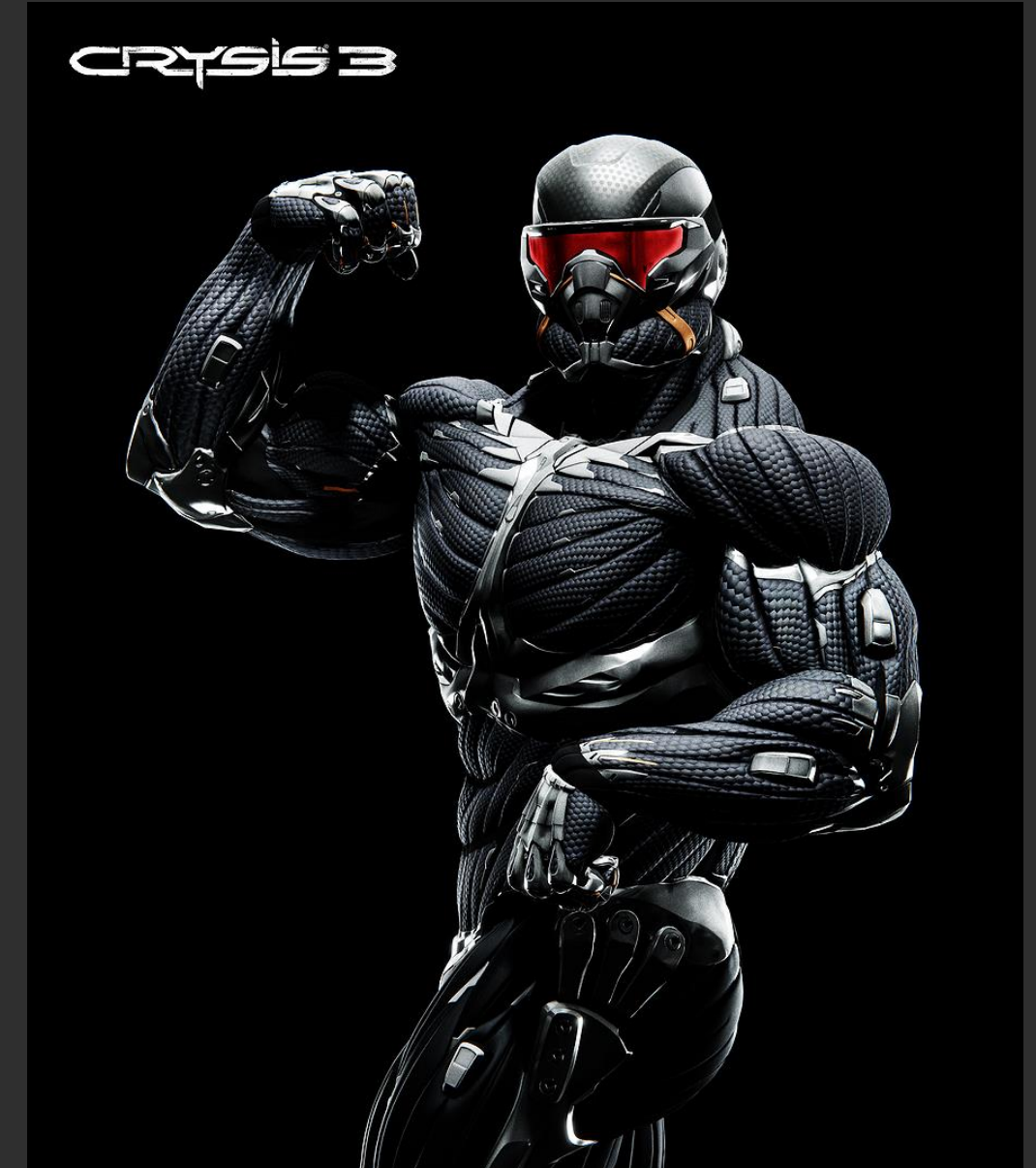
Character

Super soldier equipped with a Nanosuit

Focus

Sandbox gameplay

Visual experience



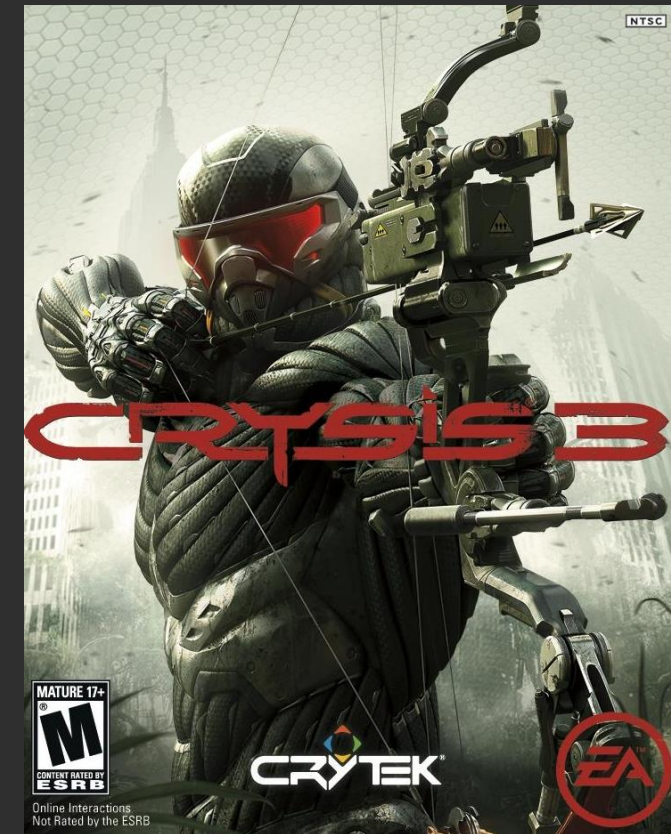
Crysis Franchise

Trilogy

Crysis 1 (2007): Awakening of an ancient alien civilization on an island

Crysis 2 (2011): Alien invasion in New York

Crysis 3 (2013): Awakening and destruction of the alien boss in New York



Production

Crysis 3 Focus

Improved graphics quality

Push the visual quality even further

Set a new benchmark for next generation games

Improved gameplay

Bigger levels

More variety

Environments

Weapons

Enemies



Initial constraints

Smaller core team

~150 people on Crysis 2

~100 people on Crysis 3

Frankfurt team

Handful of graphics programmers

Dozen of environment artists

Couple of level artists

Couple of FX artists

1 lighting artist

Initial constraints

Shorter production time

38 months for Crysis 2

23 months for Crysis 3

Create a better game

„Do better with less“

Art bottleneck

Very little place for mistakes

Art Production Overview

Pre-production

- Prototypes & concept arts

- Art benchmark level

 - Implementation of the vision of the art direction

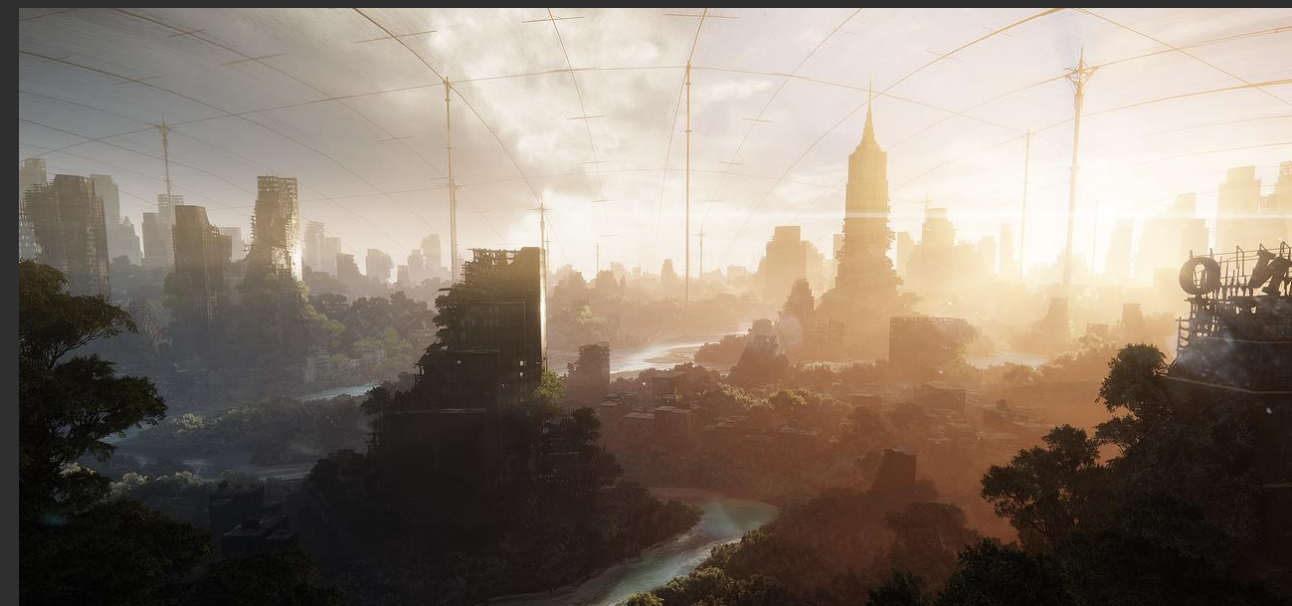
 - Improvement of the art pipeline and workflow

 - Creation of art guidelines for the full production

Full production

- Iterations and finalization

 - From white-box to final art



Concept art



Manhattan + Rain forest + Dome





Art Direction

Crysis 1 meets Crysis 2

Natural settings

Overgrown urban environment

Extremely dense vegetation

Grass fields, rivers, jungles, etc.

Lighting

Dappled lighting

Wet materials



Full production

Overview

All levels in the production pipeline at the same time

Sequential focus phases of 1 to 2 weeks for every level

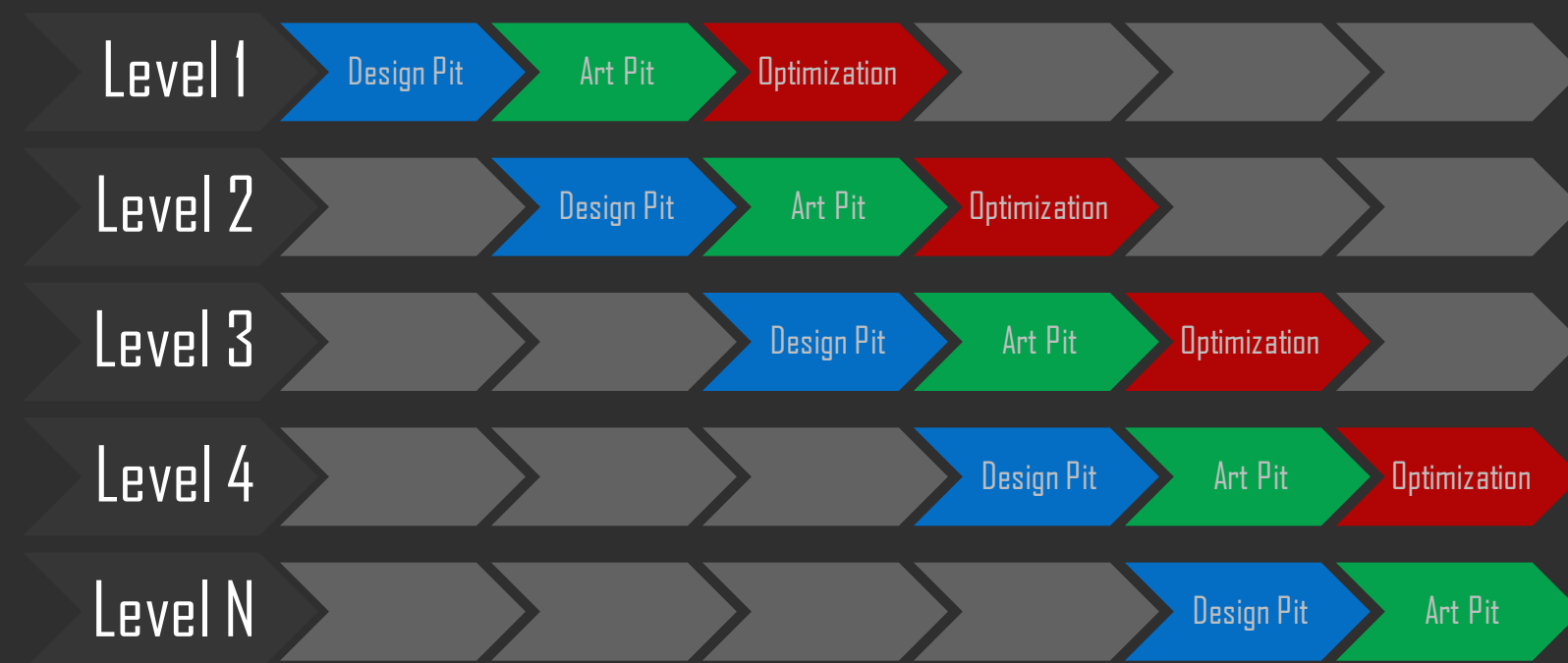
Design pit (Level design director)

Art pit (Art director)

Optimization pit (RND)

No post-production

Lighting and FX „on time“

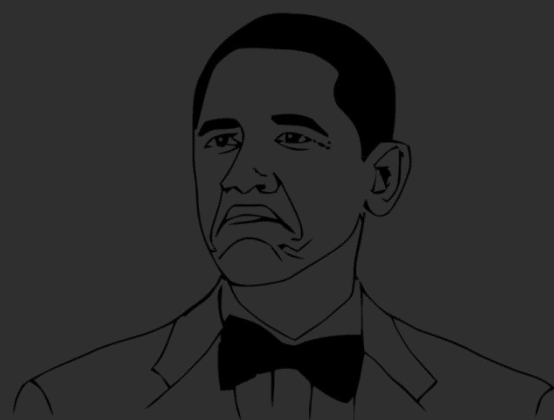


Post mortem

Tight production time

Smooth and straightforward production

Game delivered on time with a great art quality



NOT BAD

Lighting Basics

Lighting Basics

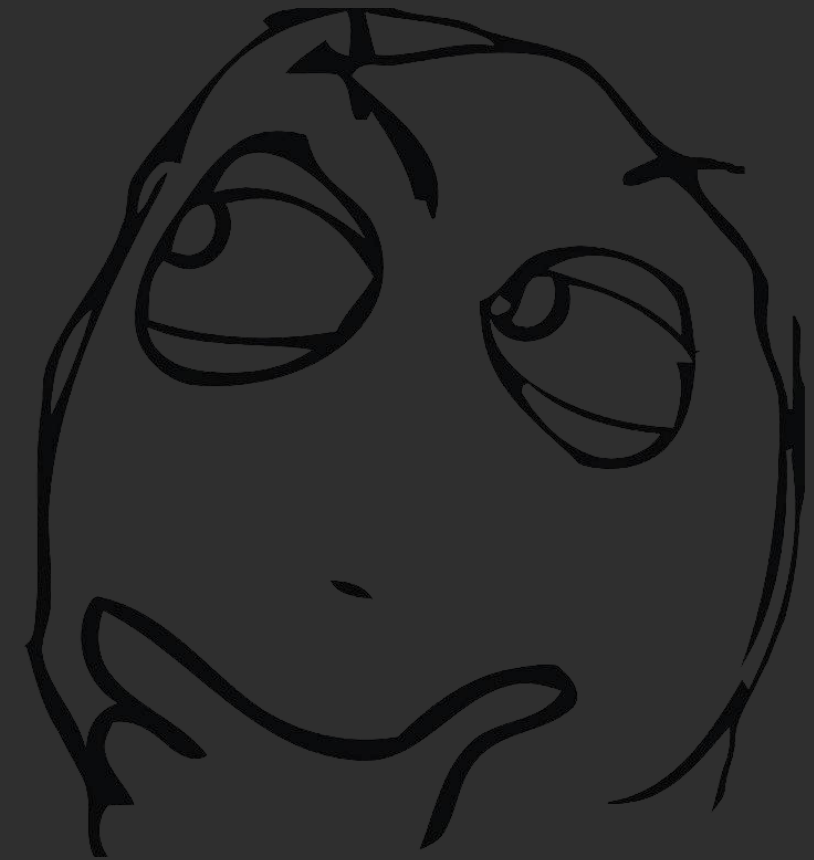
What makes lighting interesting?

Intention

Contrast

Directionality

Depth



Intention

Storytelling and emotions

Color temperature

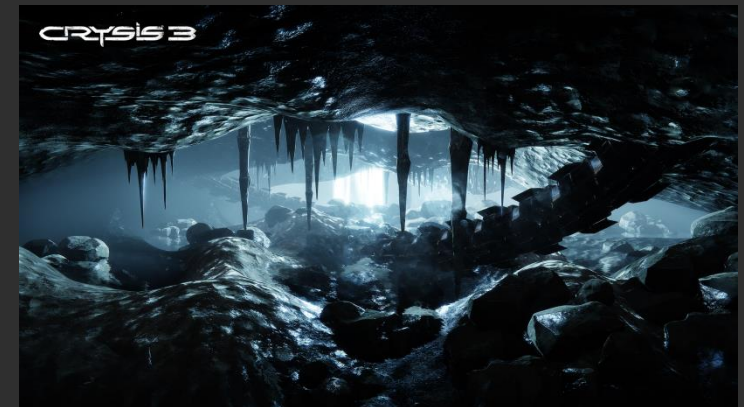
Warm tones: happiness, hope, security, etc.

Cold tones: sadness, danger, darkness, etc.

Fog

Low density: exploration, security, etc.

High density: unknown, danger, etc.



Contrast & Range

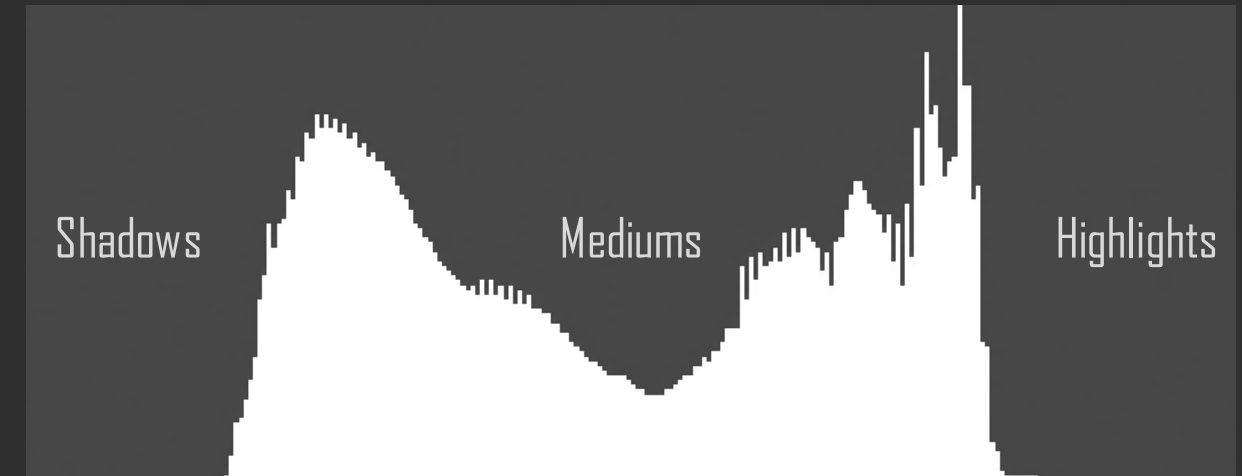
Definitions

Contrast: Difference of luminance or color in a picture

Range: Absolute difference between the darkest and brightest tones in a picture

Usual objective

Obtain a wide range and high contrasted picture

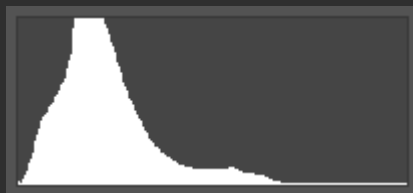


Narrow range

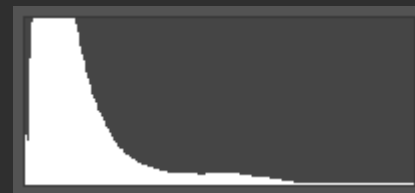


Wide range

Contrast

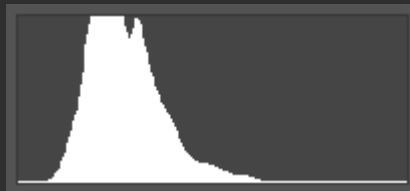


Low contrast

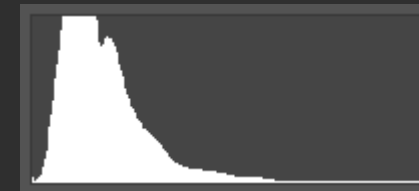


High contrast

Contrast



Low contrast



High contrast

Color Contrast

High contrast from complementary colors

Commonly emphasized tones

Cold tones

Sky

Shadows

Warm tones

Skin

Fires & explosions



Color Contrast \ Movie Posters

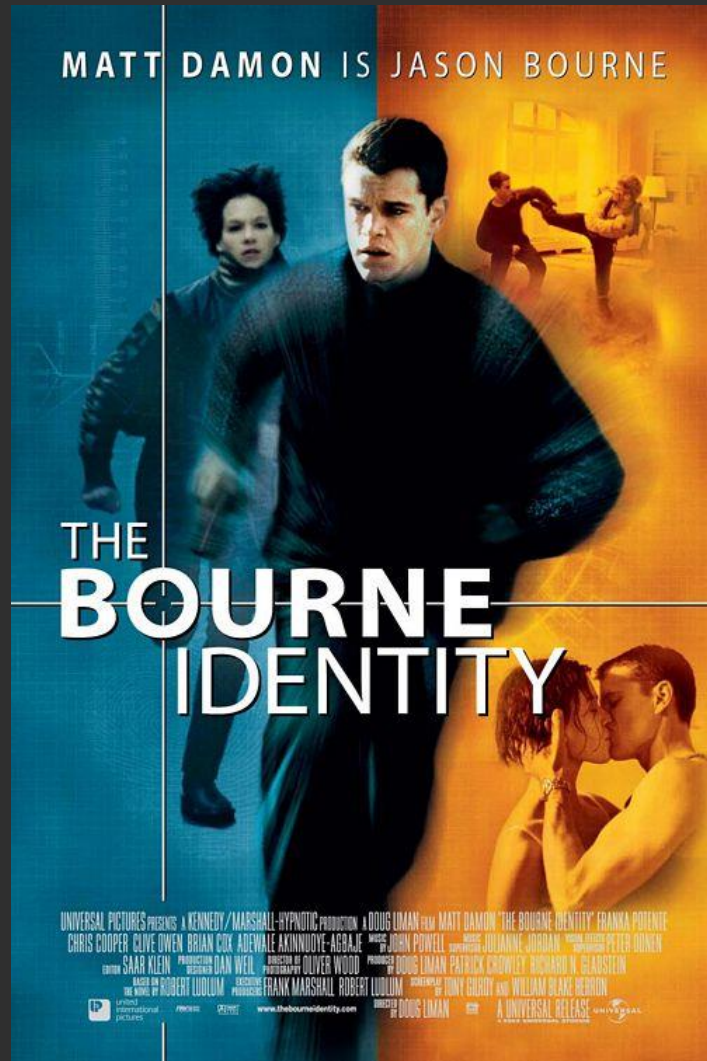
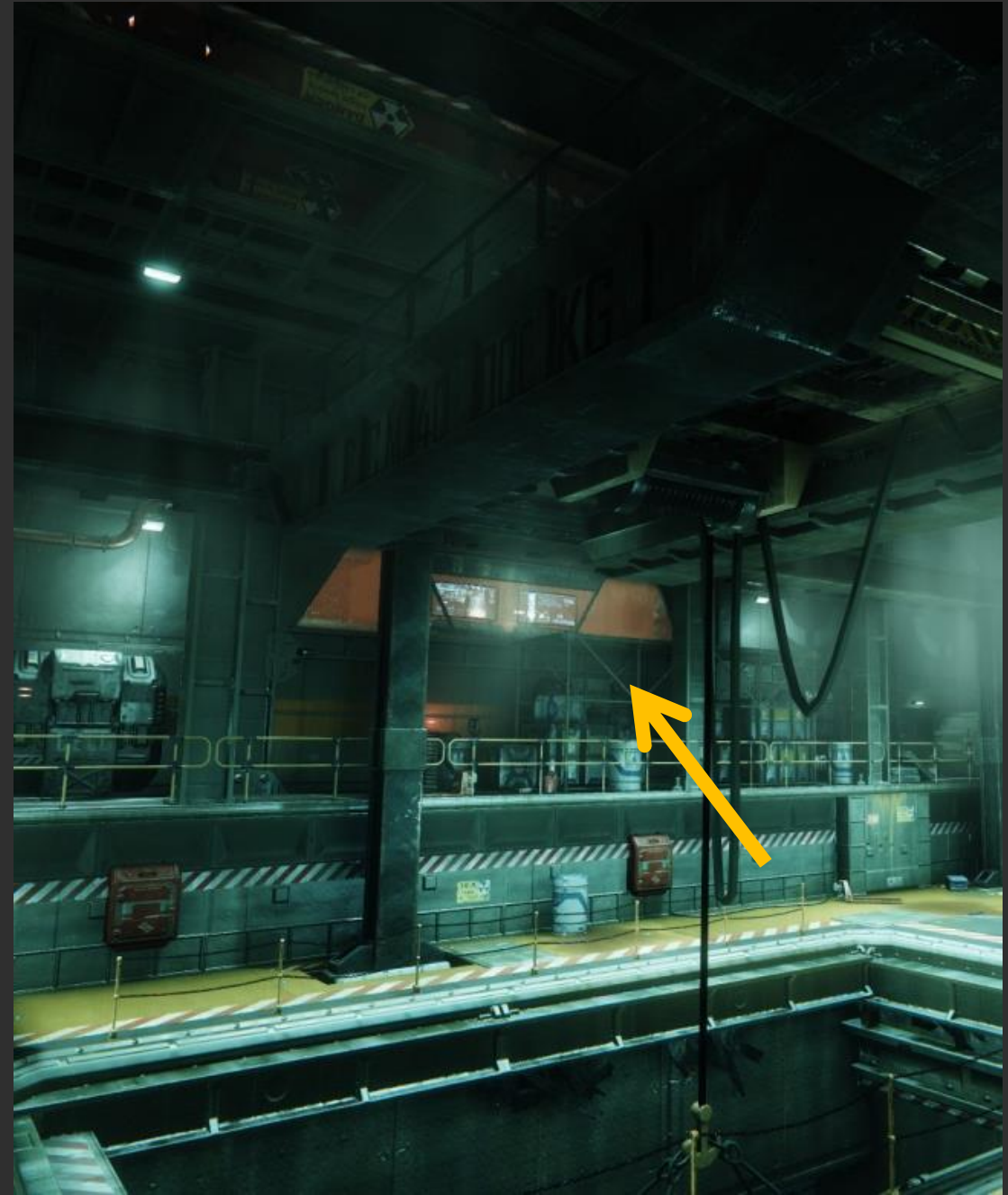


Image credits: Universal, Warner Bros, Disney & Sony

Color Contrast



Lighting Ratio

Relationship between light and darkness

Studio: key light and fill light

Outdoor: sun light and shadows



Very low lighting ratio



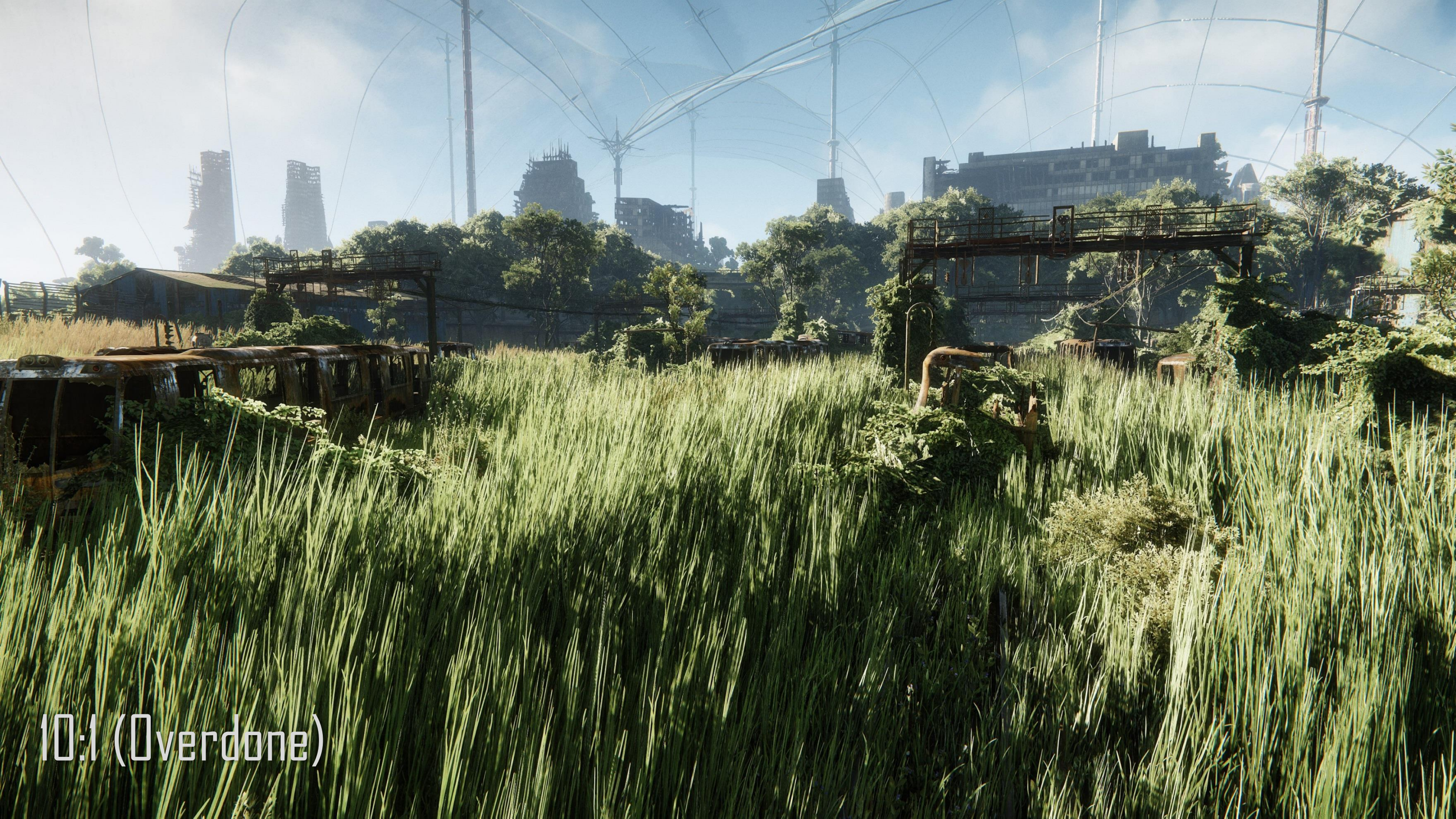
Very high lighting ratio



1.5:1 (Overcast)



4:1 (Sunny day)



10:1 (Overdone)

Directionality

Position of the key light sources

Ensure proper lighting ratio

Improvement of the player leading



Side (too high lighting ratio)



Back (too high lighting ratio)



Front left (optimal lighting ratio)



Directionality and player leading

Depth

Layers with different values or "steps"

Increased dimension factor

Separation

Readability



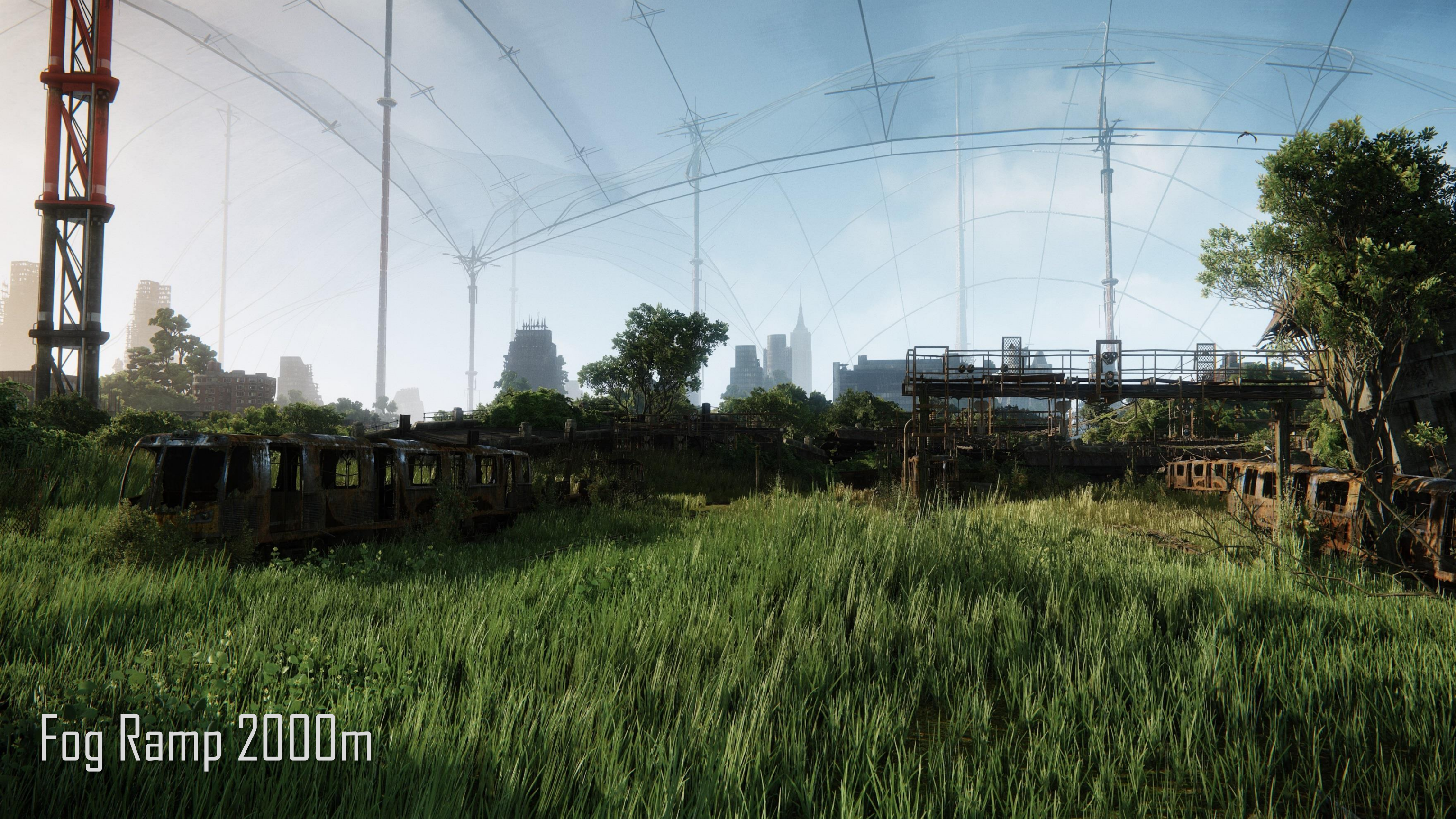
Very low depth



High depth



Fog Ramp 4000m



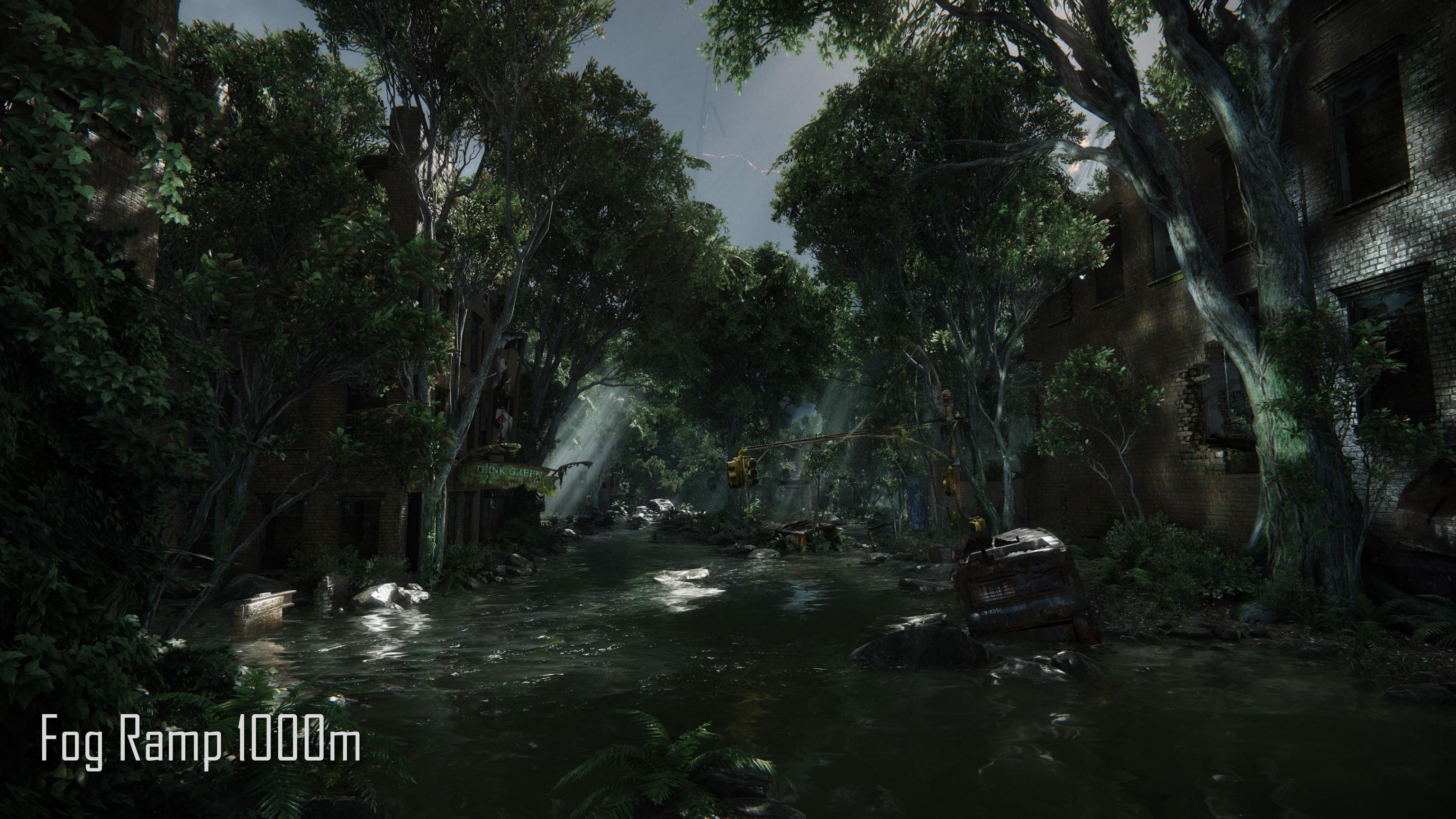
Fog Ramp 2000m



Fog Ramp 1000m



Fog Ramp 500m (final)



Fog Ramp 1000m



Fog Ramp 500m



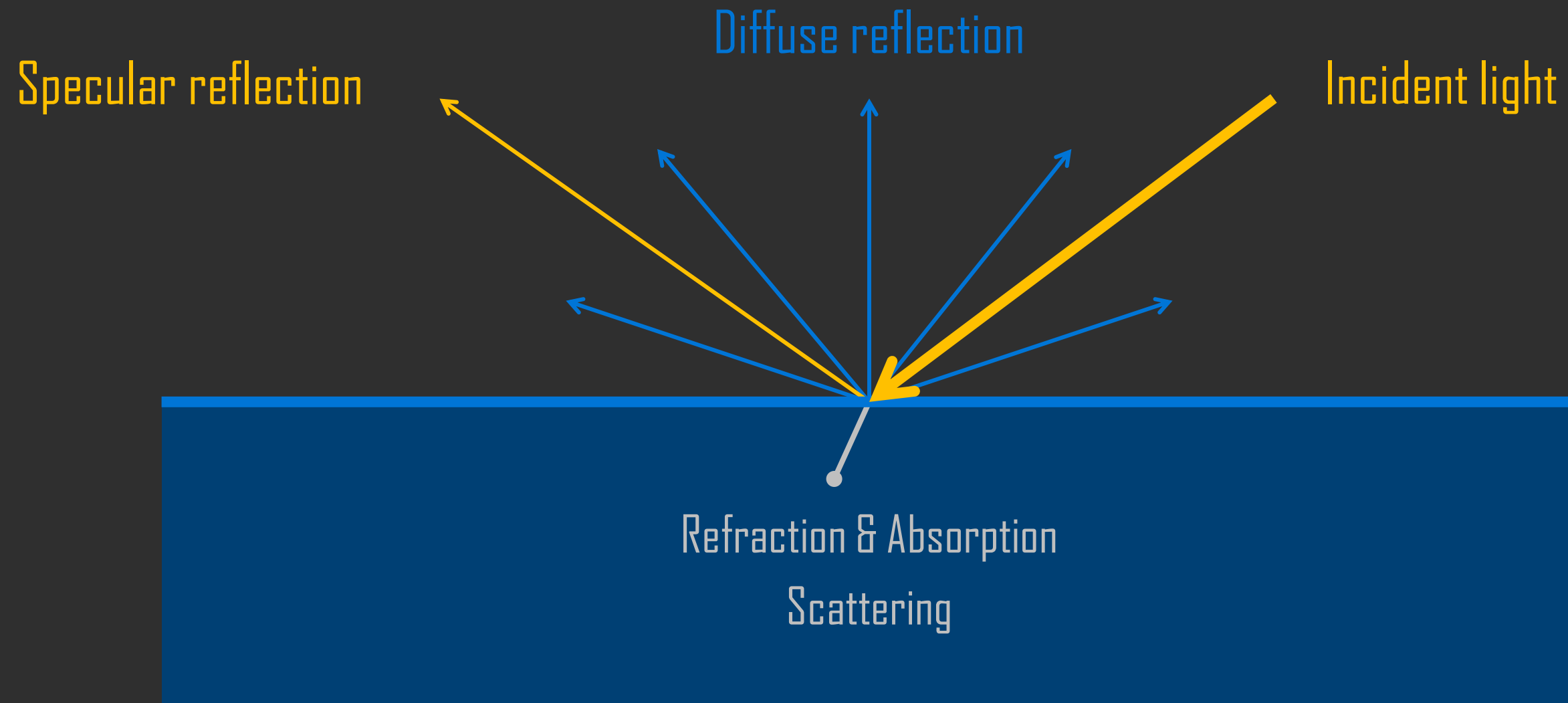
Fog Ramp 250m



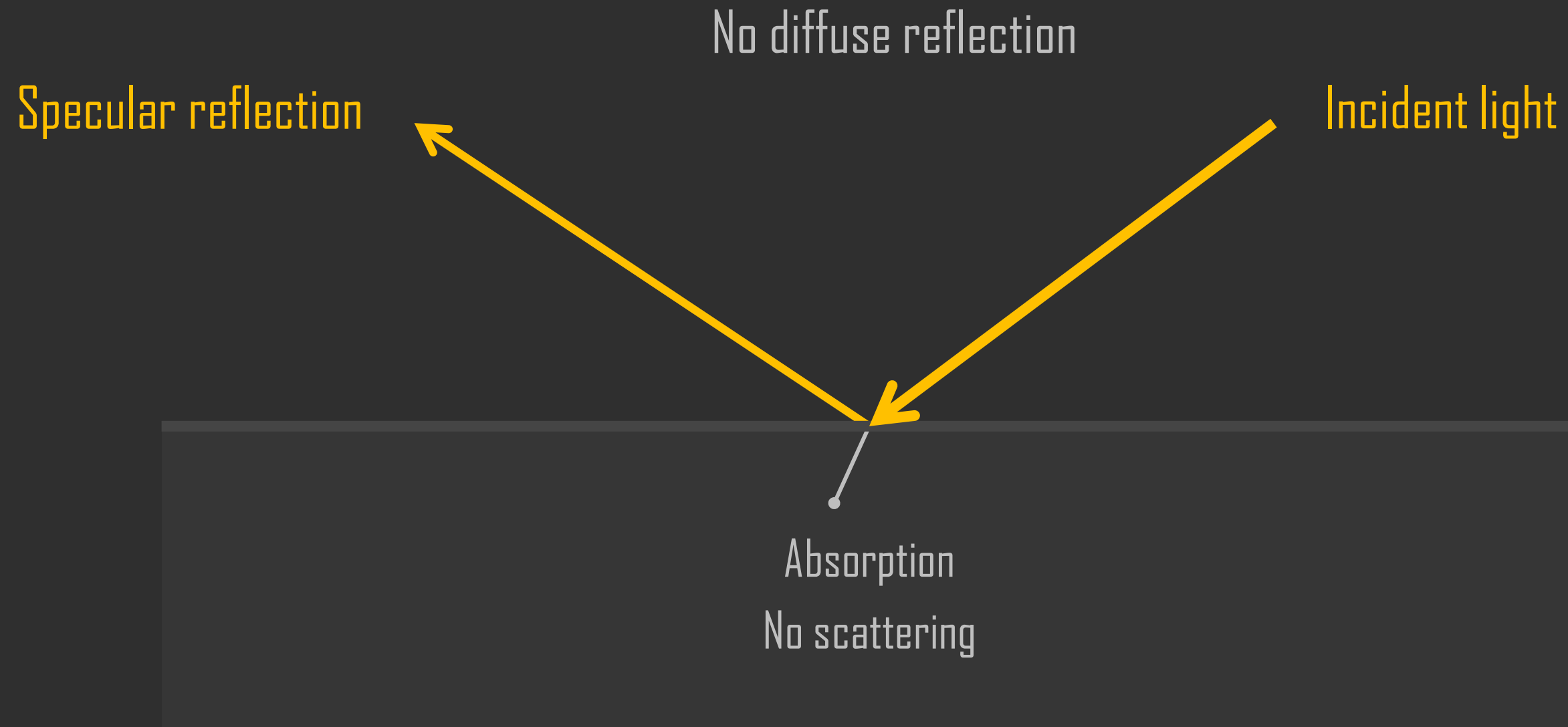
Fog Ramp 125m (final)

Physics & Materials

Non-Metals Overview

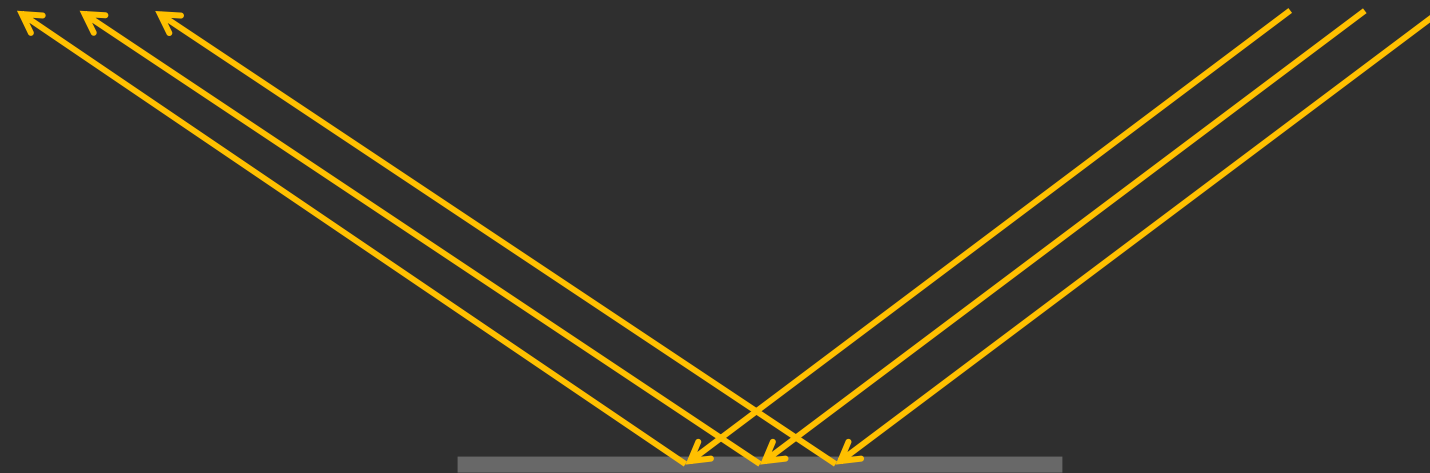


Metals Overview



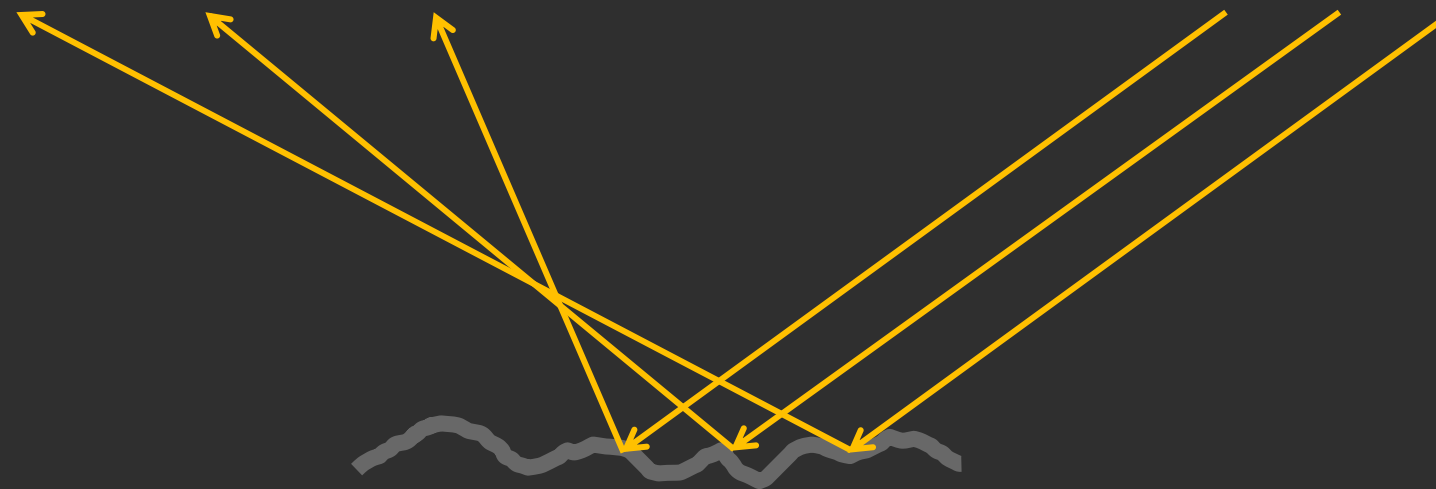
Surface Roughness

Sharp reflections



Polished surface

Blurry reflections



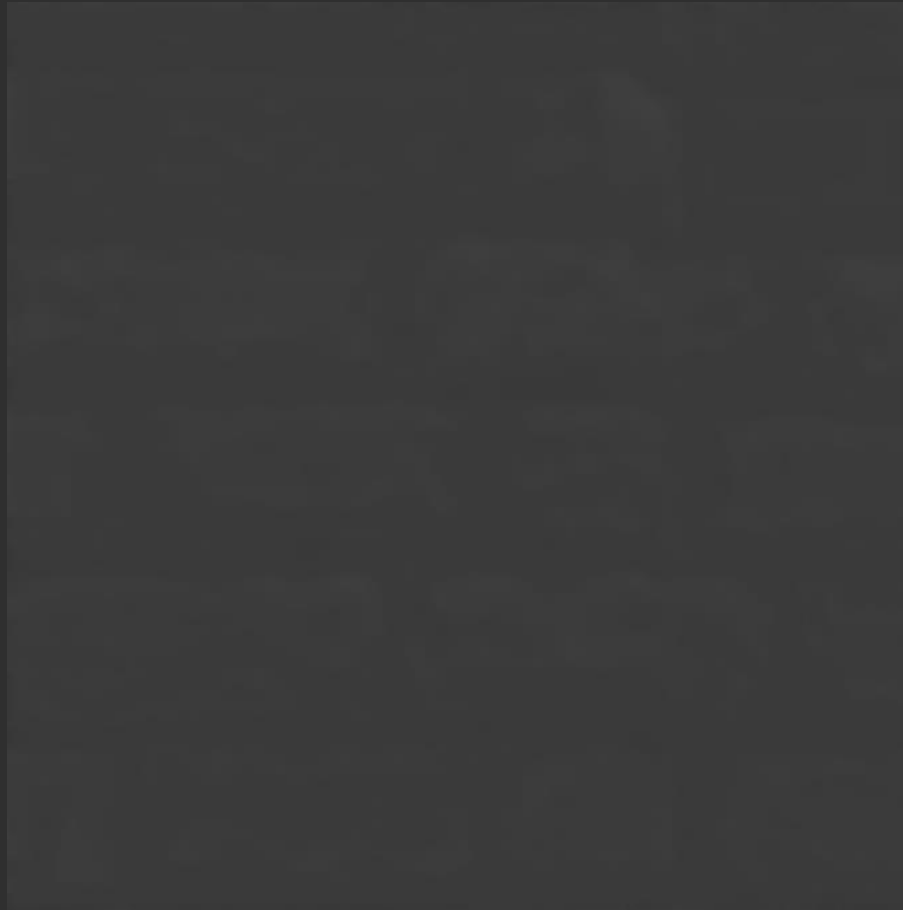
Rough surface

Materials

Diffuse texture



Specular texture



Glossiness/roughness texture



Specular Textures

Common mistakes

Total lack of consistency between the specular textures

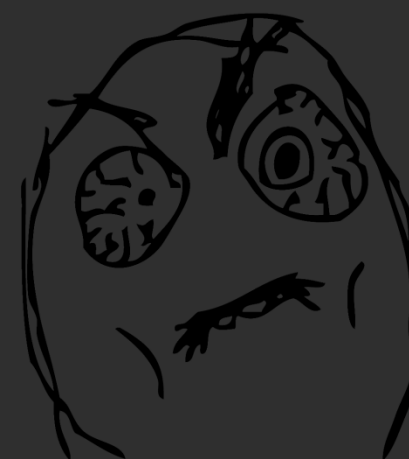
Specular texture created from a diffuse texture (grey-scale & high contrast)



Diffuse texture



Bad specular texture



Solution

Physically-based approach

Augustin-Jean Fresnel

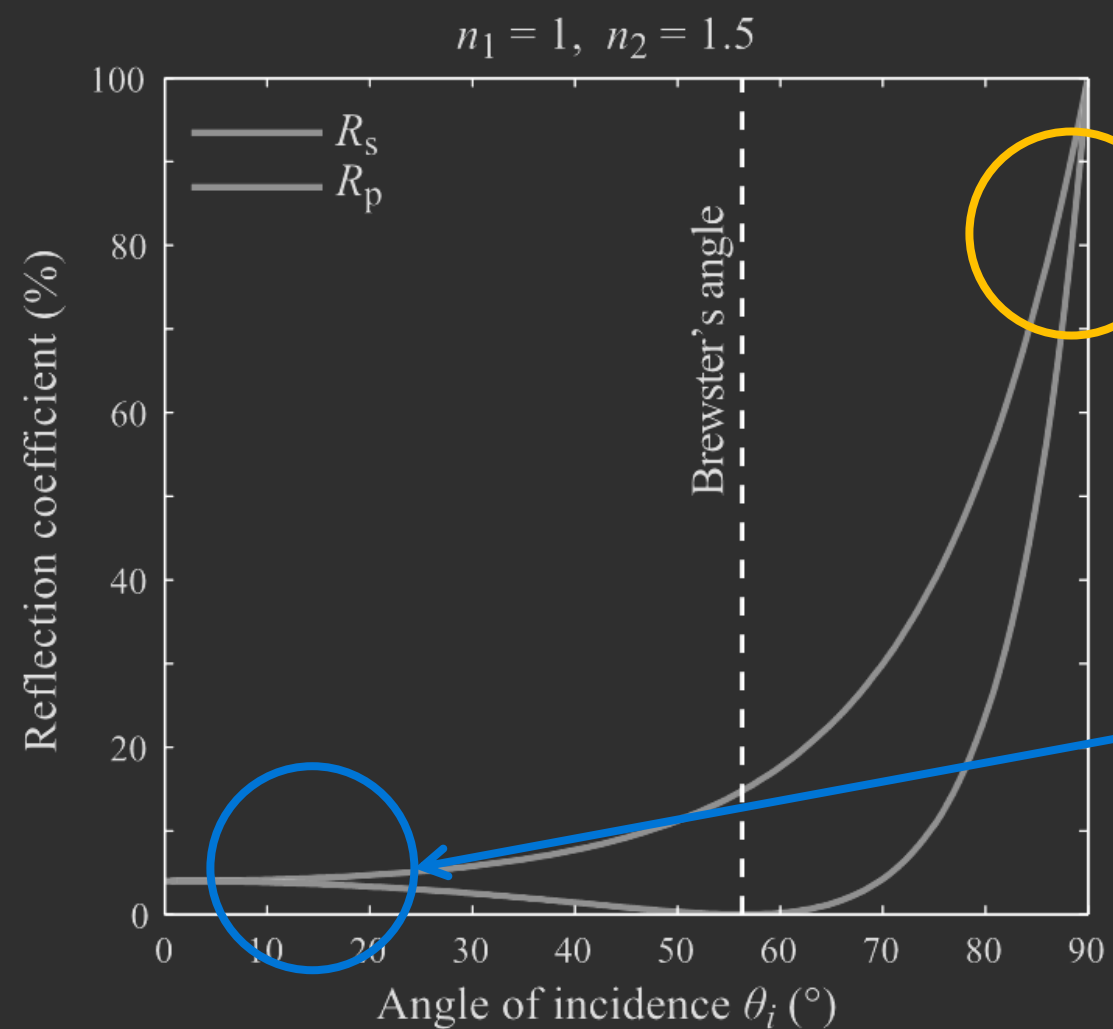


Augustin-Jean Fresnel
(1788–1827)

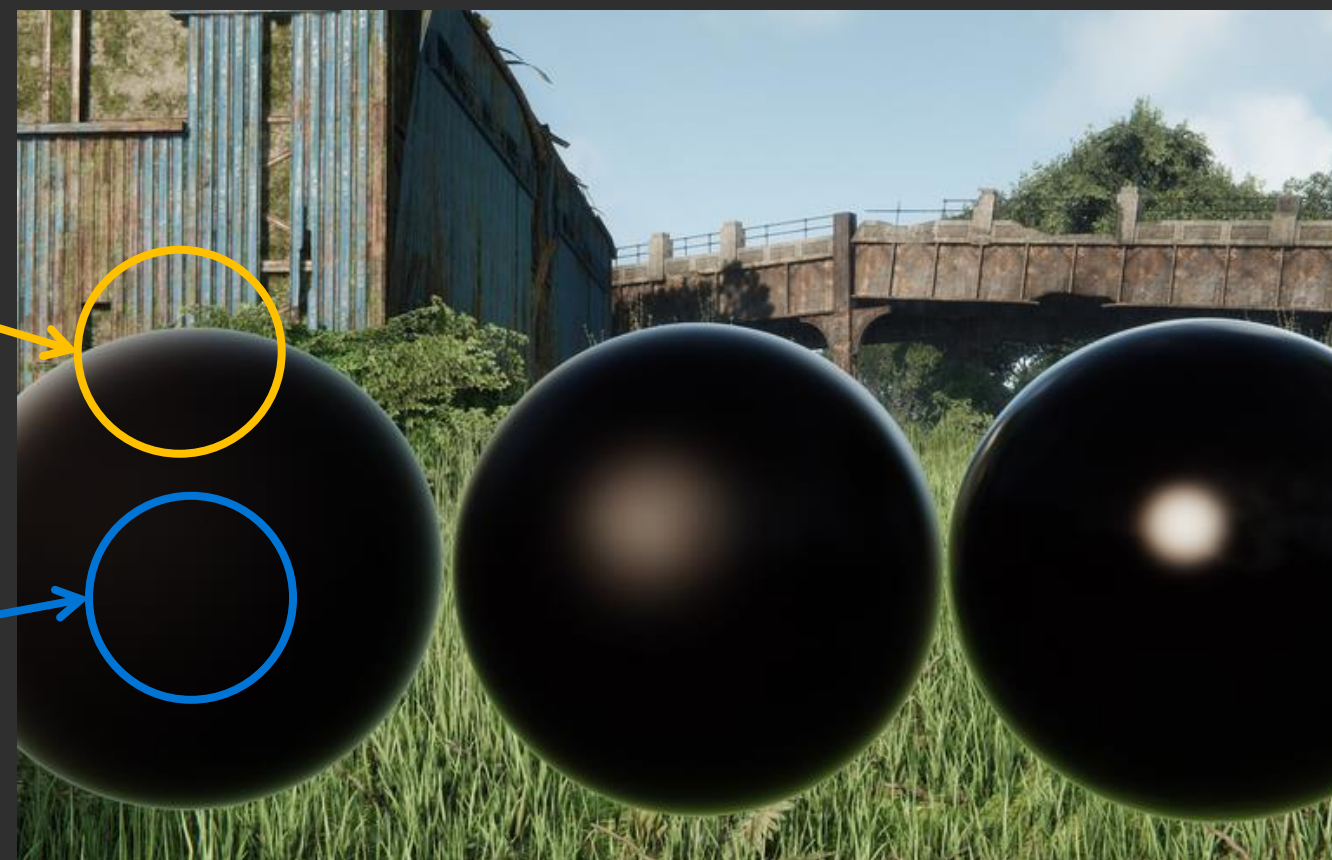
"The stronger the angle of incidence of the light, the stronger the reflection."

Image credit: Wikipedia

Fresnel Effect



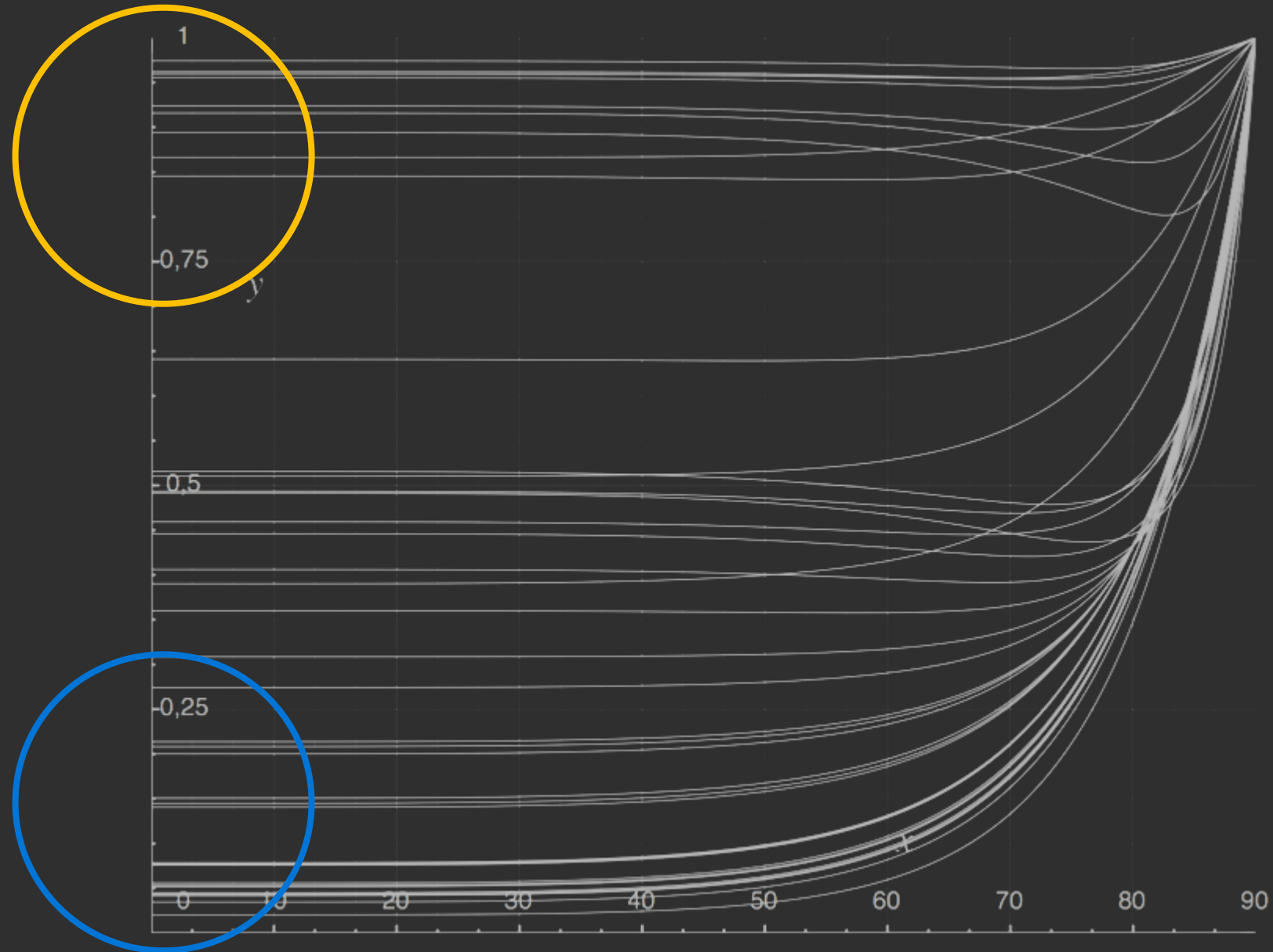
Reflection coefficient of a non-metal



Black plastic spheres

Reflection Coefficients

Metals



Non-metals

Physically-Based Specular Color

Specular luminance [0;255]

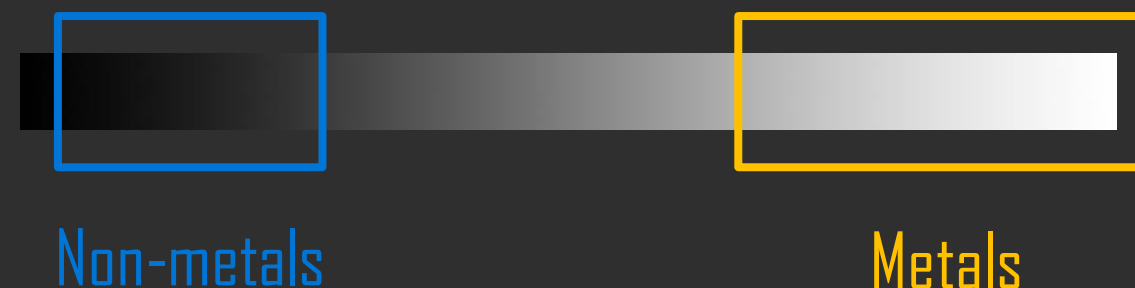
Most non-metals: 20-70

Metals: +180

Specular color

Non-metals: grey-scaled

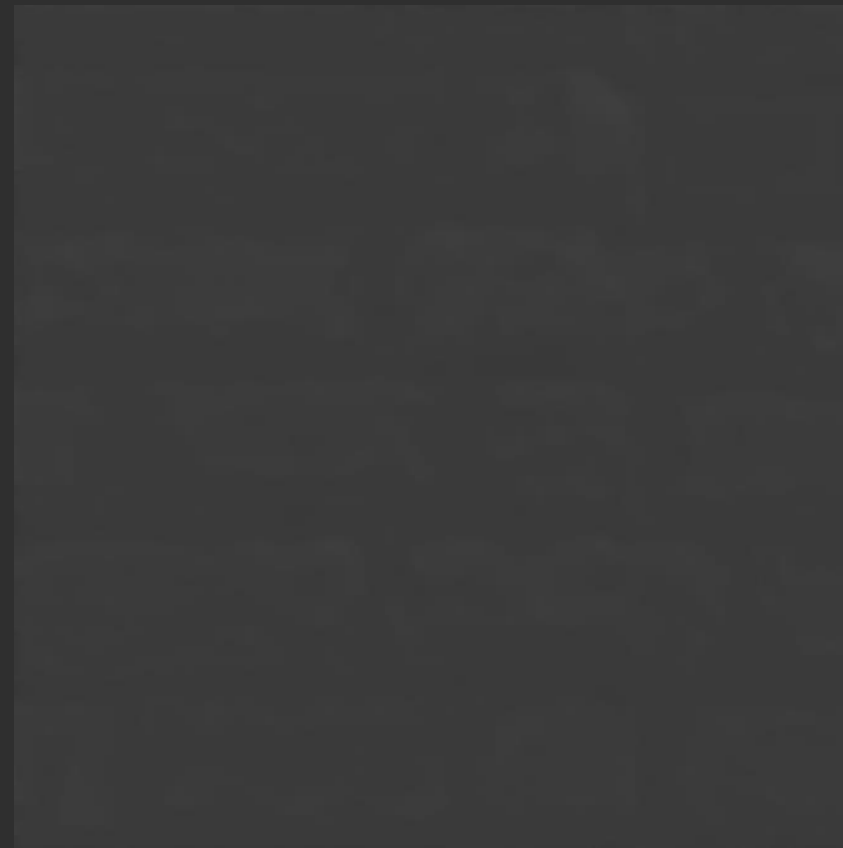
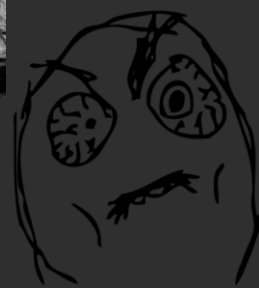
Metals: slightly colored (gold, copper, nickel)



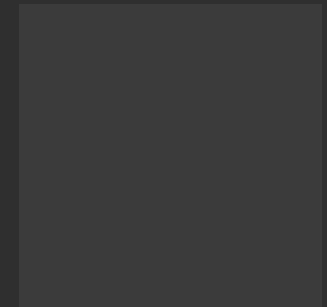
Physically-Based Specular Texture



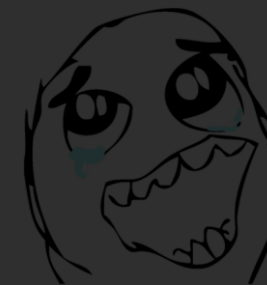
Diffuse-based specular texture



Physically-based specular texture



Physically-based specular color



Glossiness \ Roughness

Roughness defined by a value [0;255]

Uniform roughness



Glossiness range

Roughness defined by a glossiness texture

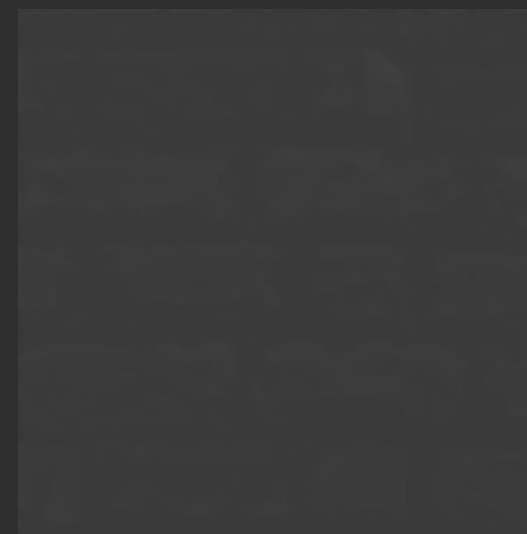
Very important for material definition

More artistic freedom for painting details

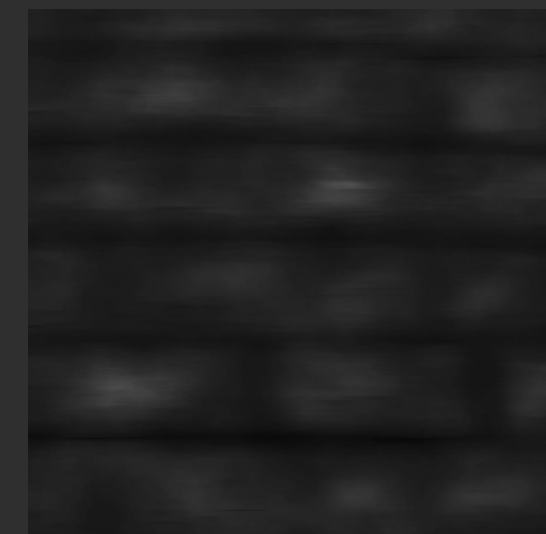
Scratches

Specles

Wet areas



Specular texture



Glossiness texture

Diffuse Textures

Common mistakes

- Visible light & shadows
- Too strong ambient occlusion
- Too high contrast

Work done by the engine

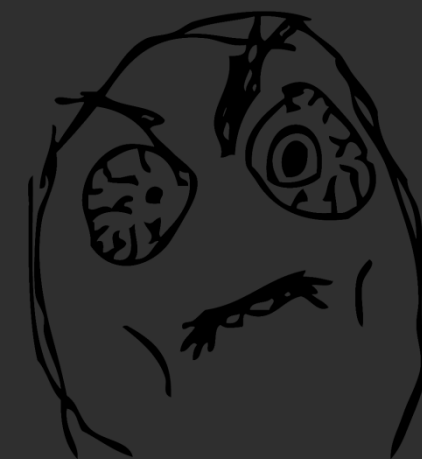
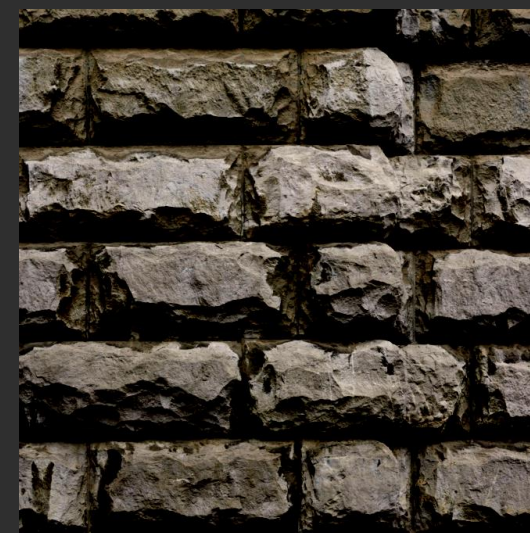
- Lighting & shadows
- Ambient occlusion
- Postprocessing

Solution

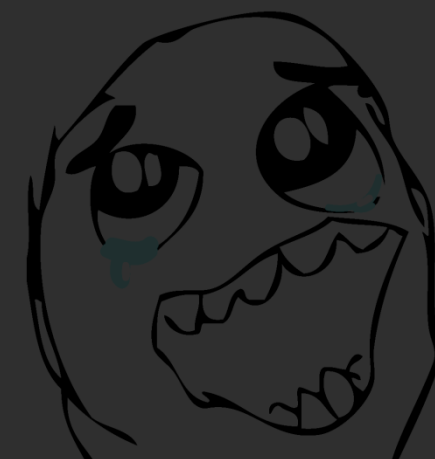
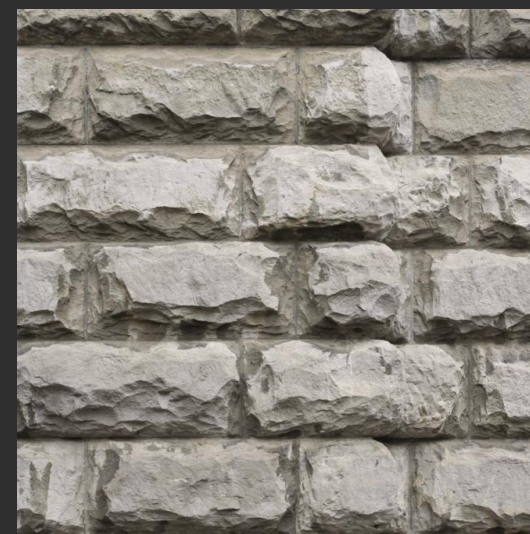
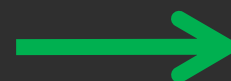
- Lighting control during capture
- Calibration during and after capture



Bad diffuse texture



Good diffuse texture



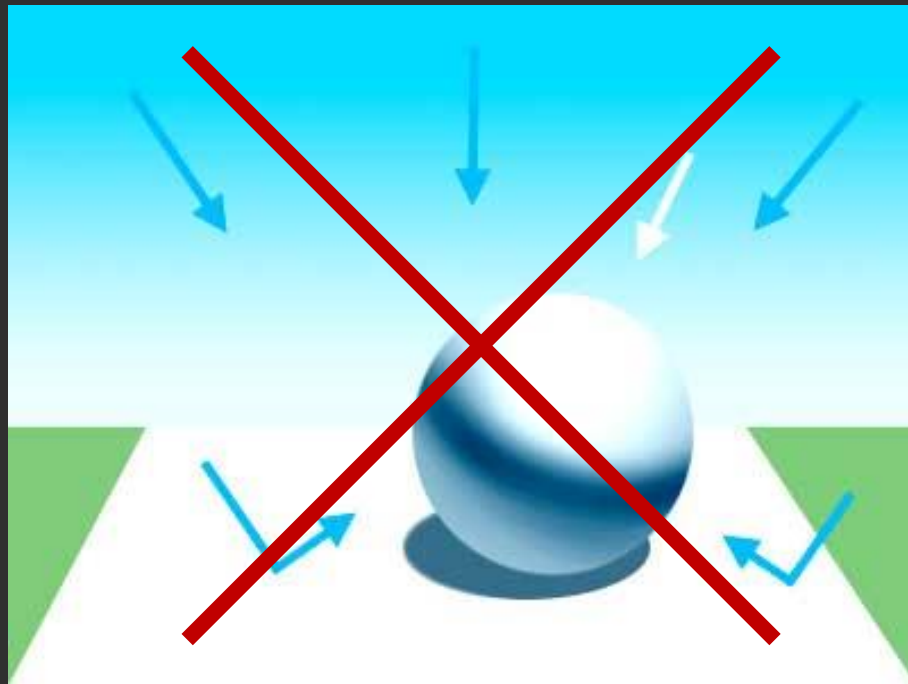
Diffuse Textures\Capture

Minimize lighting information in the textures

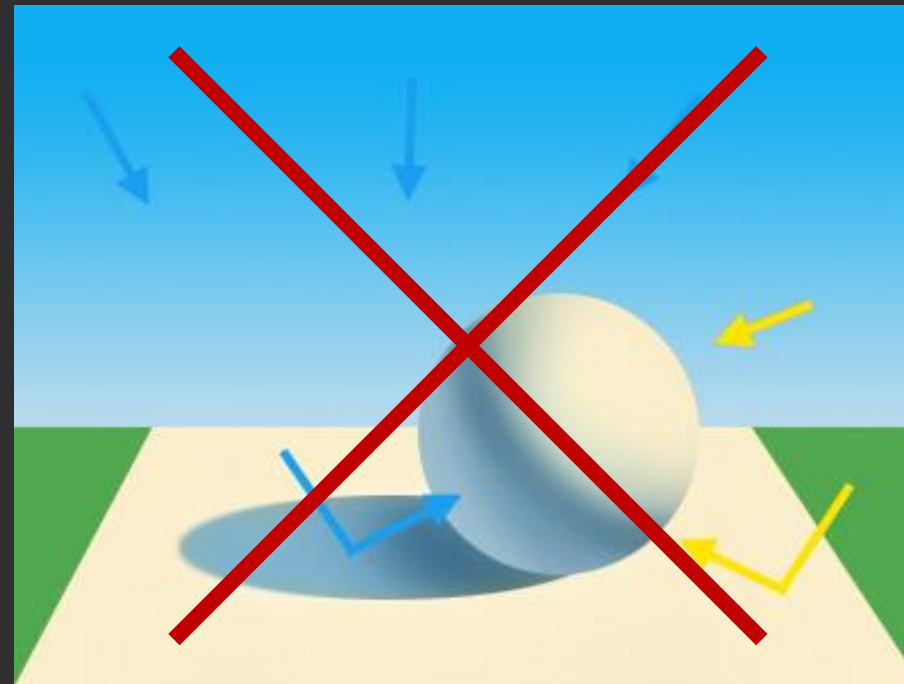
Prevent strong direct light

Ensure neutral color balance

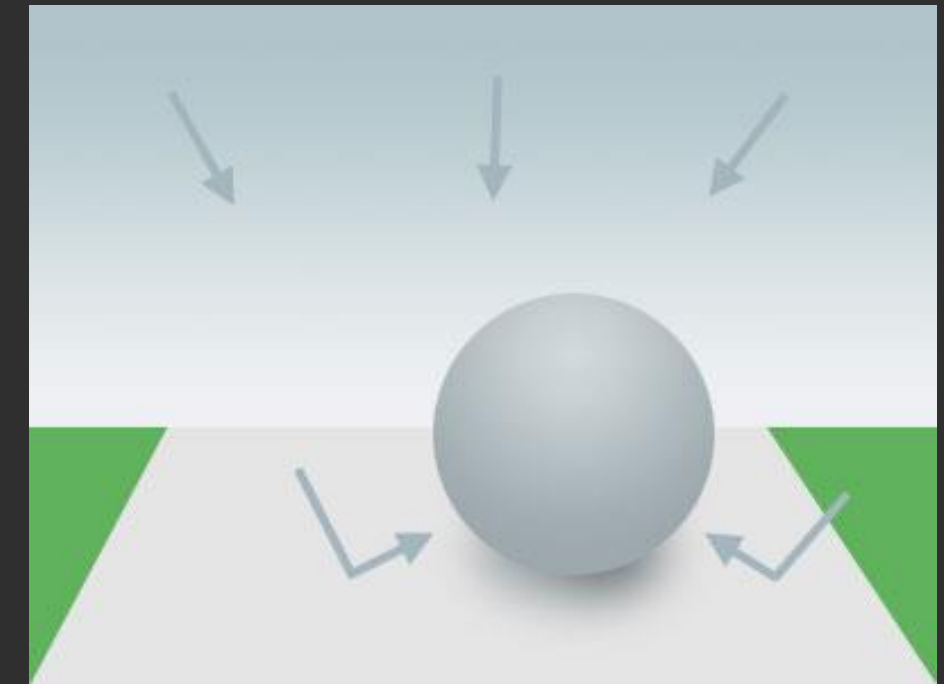
Ensure flat consistent lighting



Bright daylight



Low sun settings

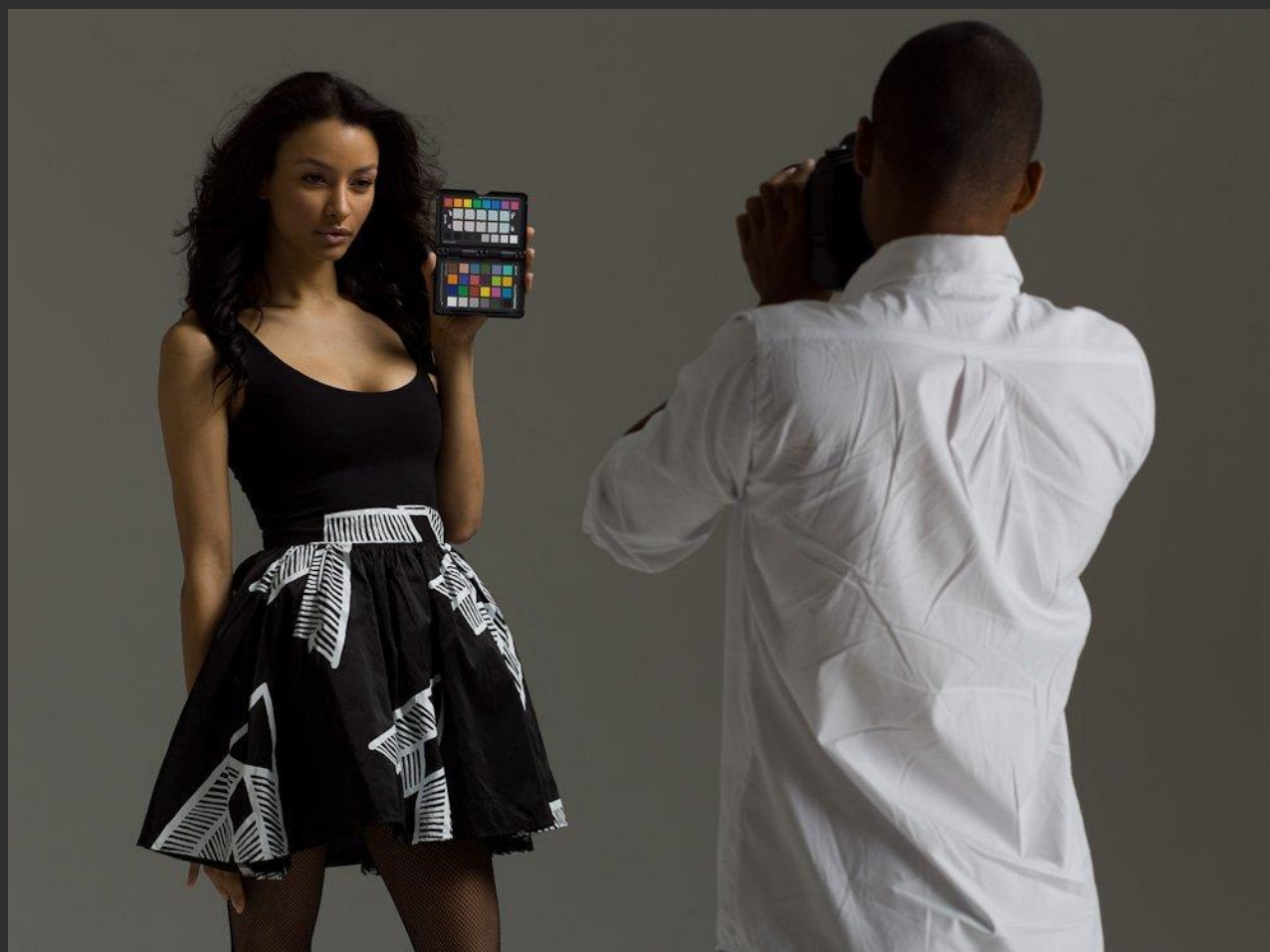


Overcast

Image credits: Richard Yot, www.itchy-animation.co.uk

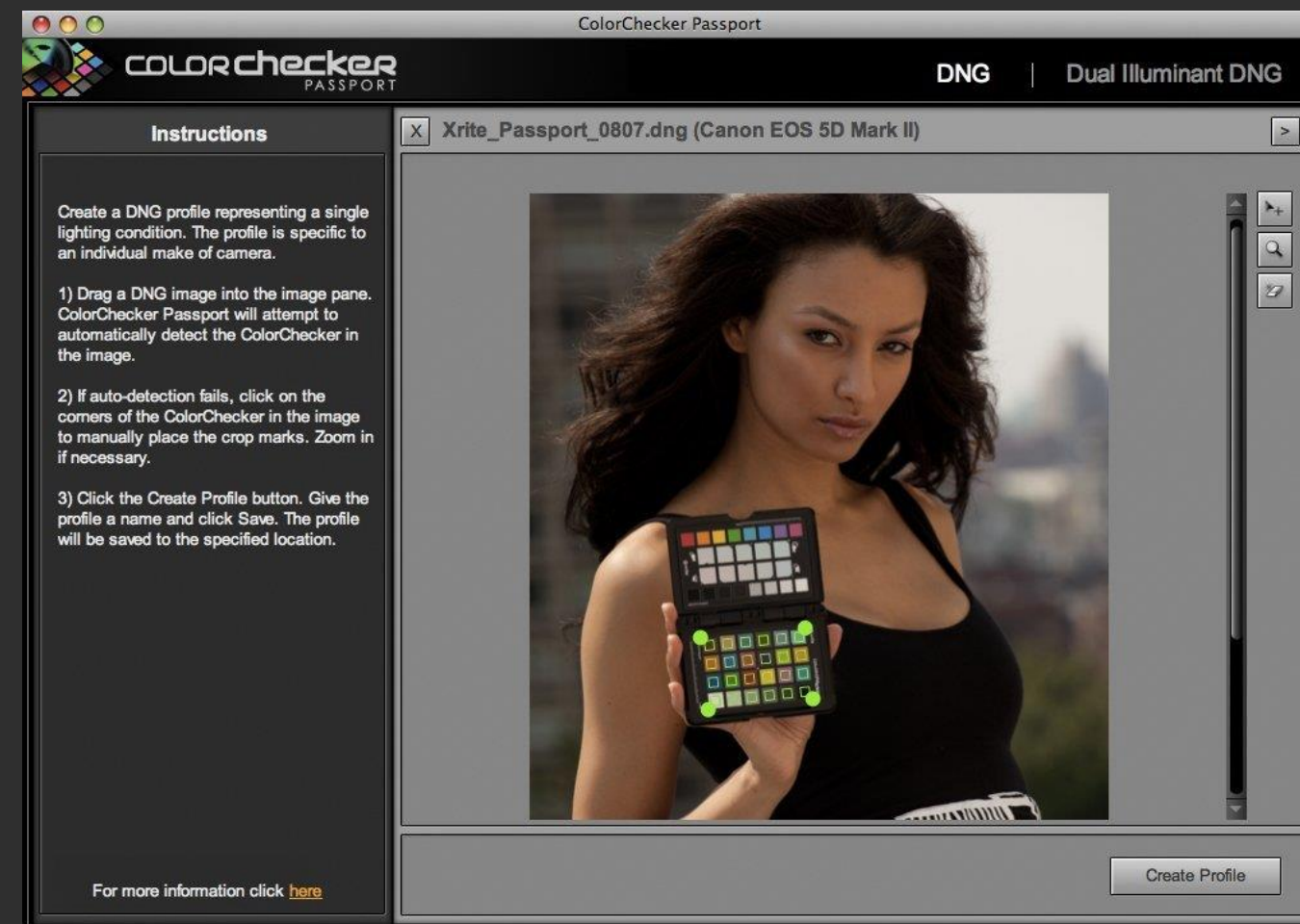
Diffuse Textures\Calibration

Shoot reference with color checker



Hold the color checker perpendicular to camera
(Minimize Fresnel effect)

Automated or manual software correction



Adjust white balance, levels and colors

Image credits: X-Rite, xritephoto.com

Diffuse Textures\Reference Library

Calibrated reference textures for proof checking

Based on the most representative textures of the game world

New textures consistently tweaked to fit the reference textures

Lighting calibration based on the reference textures



Vegetation

Mud

Rust

Metal

Rusty stone

Concrete

Bricks

Average

Mirror

Calibrate key textures only

No need to calibrate 10'000 textures

Trust your eyes for the rest

Art Production Guidelines

Asset Zoo Level

Test level for proof checking assets

Level based on the Art Benchmark level

Check assets consistency at a glimpse with multiple lighting debug modes

Store all assets in one single level



Asset Zoo Level\Flat shading

Pure flat indirect lighting

Control the consistency of the diffuse textures

No post processing, no reflection, no ambient occlusion, no fog



Standard lighting mode



Flat shading mode

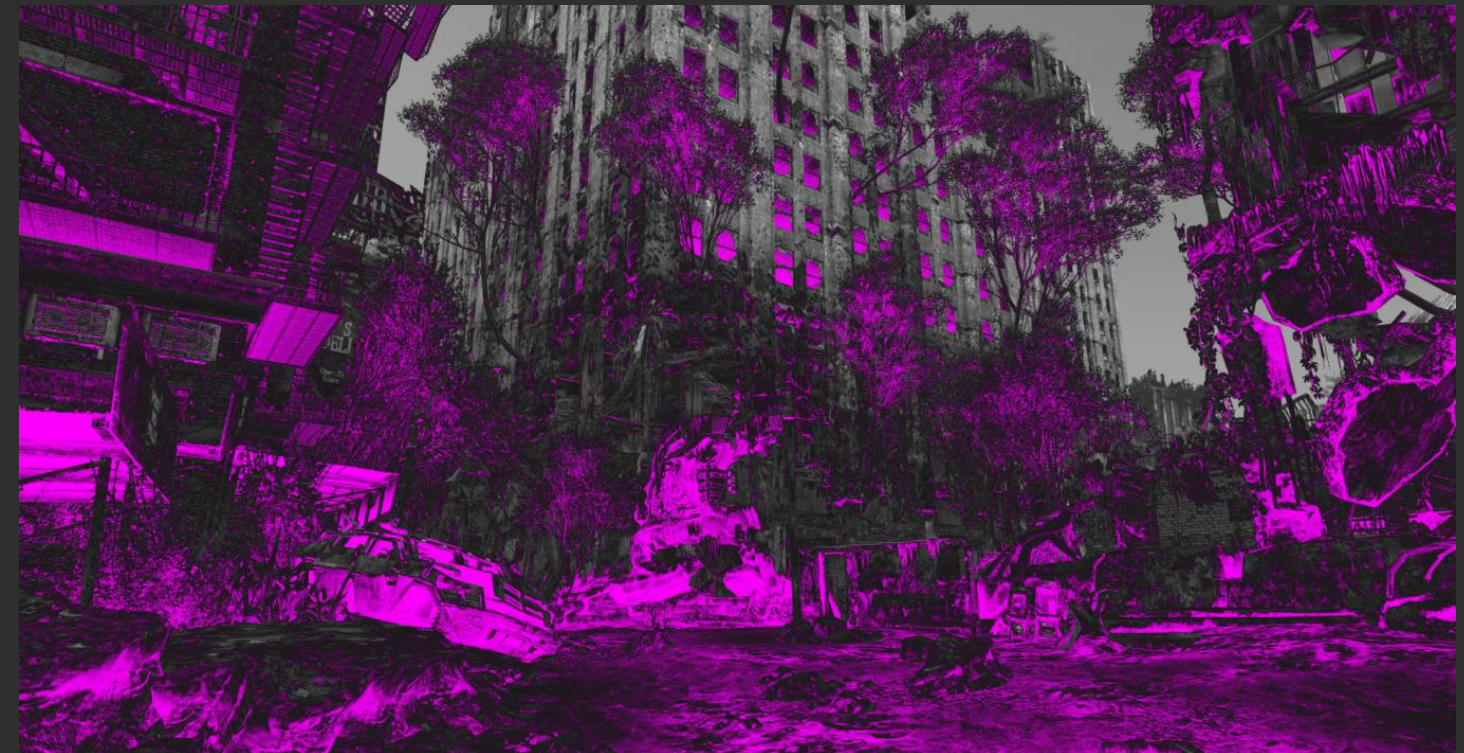
Asset Zoo Level\Clipping Control

Visualize blacks and whites clipping

Good estimation of clipping on TVs with limited color space (16-235)



Flat shading mode



Clipping control mode

Asset Zoo Level\Clipping Control



Black: RGB 0-15

White: RGB 240-255

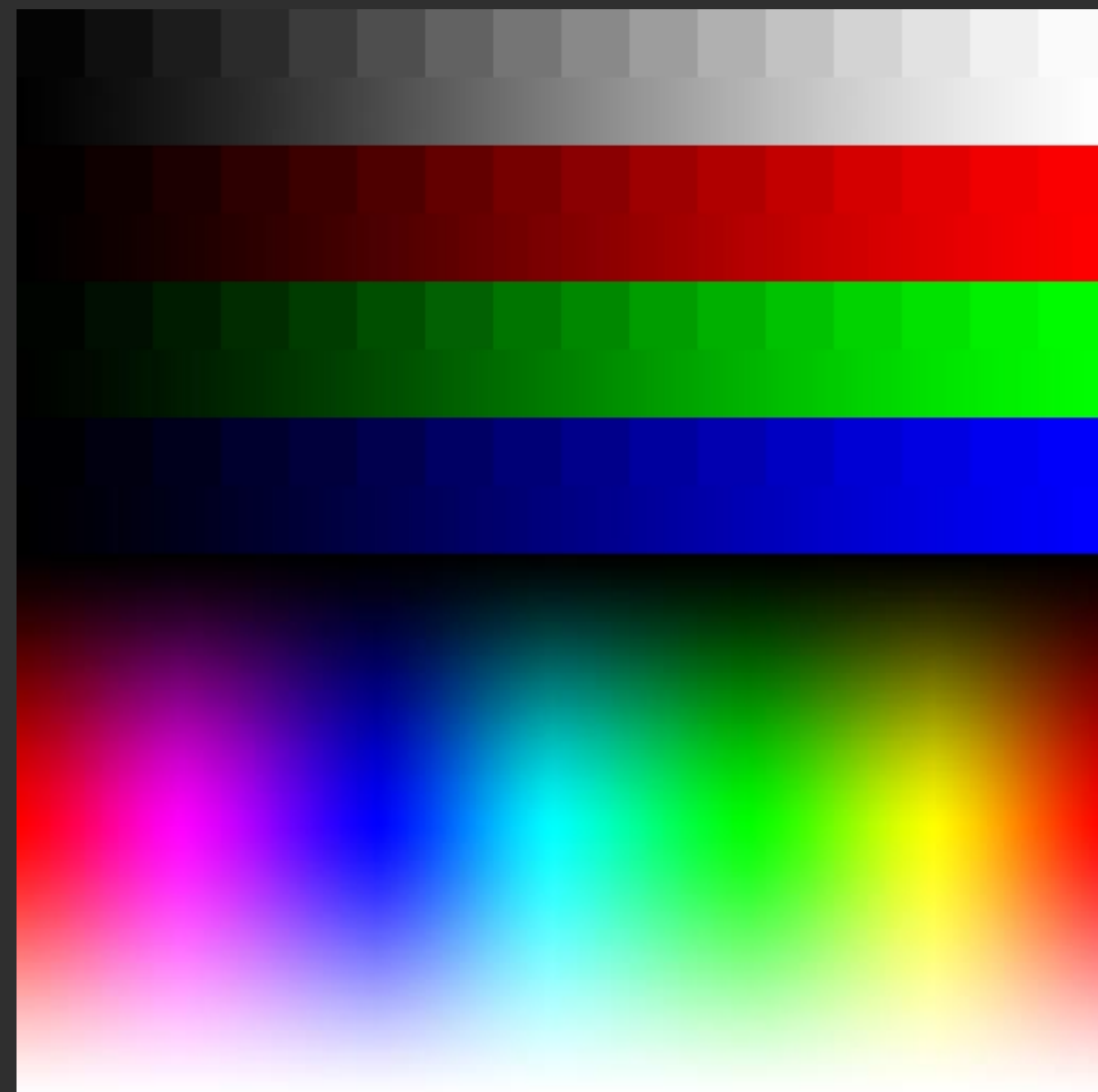
Lighting calibration

Gamma chart and color gradient chart

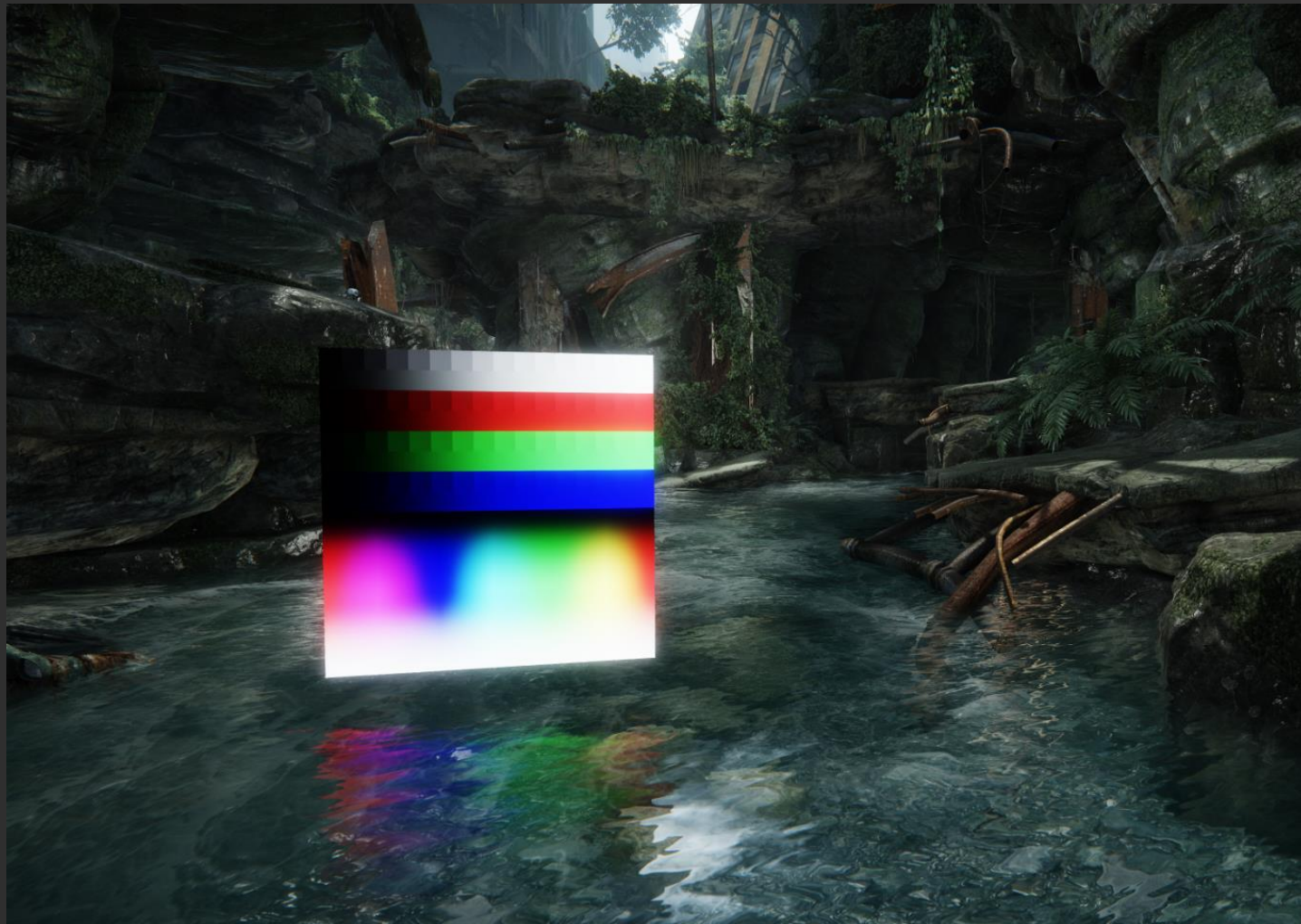
Control lighting influence on the textures

Control Post FX influence on the colors and white balance

Prevent clipping of the blacks and whites



Lighting calibration



Monitors

Ensure all artists work with proper monitors (IPS, *VA or PLS panels)



View angles of low end monitors (TN panels)



View angles of higher end monitors (IPS panel)

Calibrate all monitors to industry standards to ensure consistency across workstations

sRGB, Gamma 2.2, 6500K and $\sim 100\text{cd/m}^2$

Image credits: www.anandtech.com

Monitors & TVs

Most gamer monitors

- TN panel technology
- Terrible vertical view angles
 - Overall Gamma depending on sitting height & screen inclination
- + Very low reaction time (~2ms)

Most televisions

- Terrible color settings with dynamic contrast & sharpening
- Reduced output range (16-240 or 16-235)
- HDMI mess in consoles settings (Standard, Extended, etc.)
- + Acceptable "Cinema" settings

Lack of standardization for visual equipment

- For sound systems: THX certification
- For displays: ?

Why care about colors then?

- Consistency within the company between work and review stations

Real-Time Lighting Features

Real-Time lighting

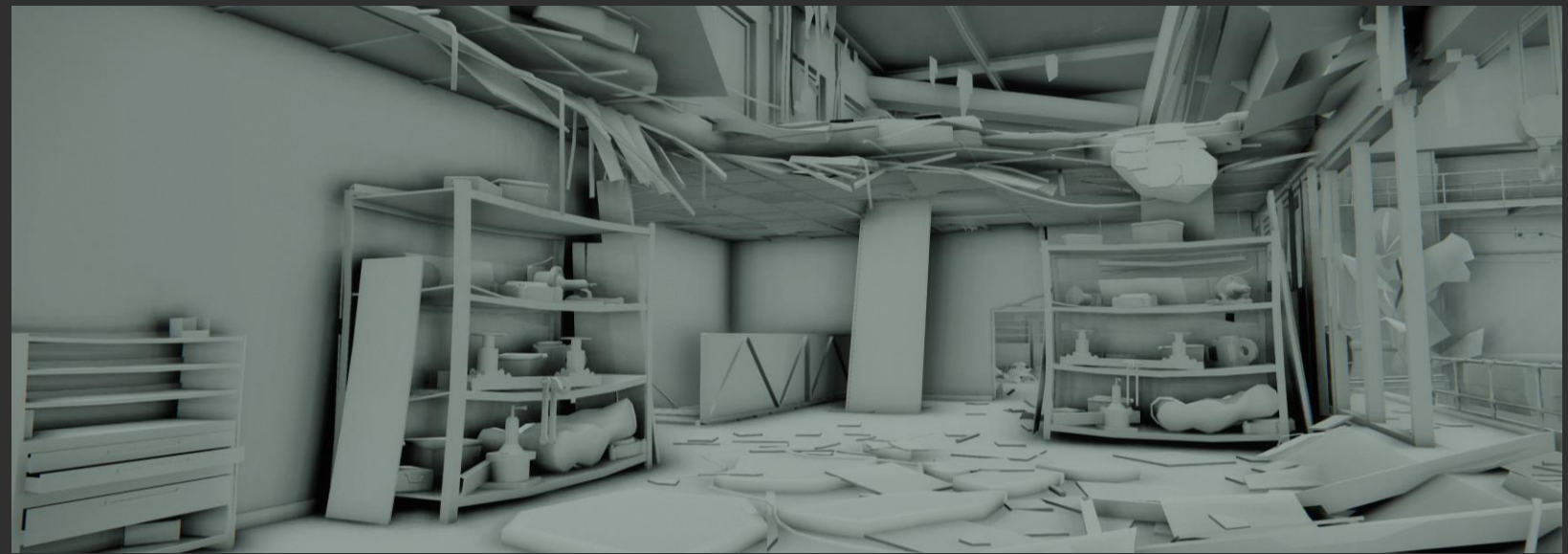
"Real-time, all the time"

HDR Lighting, shadows & atmosphere

HDR Image-based lighting

Ambient occlusion

Global illumination



Rendering Techniques

Forward rendering

Every object shaded sequentially

Multiple passes required for multiple light sources

Issues

Waste of resources on pixels covered by multiple objects

Waste of resources complex scenes (many objects and lights)

Complexity

Amount of geometries * amount of lights

Typical usage

World with low light sources usage (sun)

Older hardware (no MRTs support)

Deferred rendering

Geometry and lighting data extracted from the scene

G-Buffer (geometry) and L-Buffer (lighting)

Every pixel shaded in one pass

Issues

Forward passes required for complex shaders and transparency

Difficulty to exclude lights from certain objects or areas

Complexity

Amount of pixels * amount lights

Typical usage

Lighting heavy scenes (interior)

Deferred rendering

Hybrid deferred rendering in CryENGINE

Most of the shading processed in one single pass (opaque geometry)

Forward pass still required for transparency & complex shaders (hair & skin)



Final frame



Deferred (Red) & Forward (Green)

Deferred rendering\G-Buffer



Albedo YCbCr (RG)



Specular (B)



Depth



Normals (RG)



Glossiness (B)



Translucency (A)

HDR Lighting

High precision

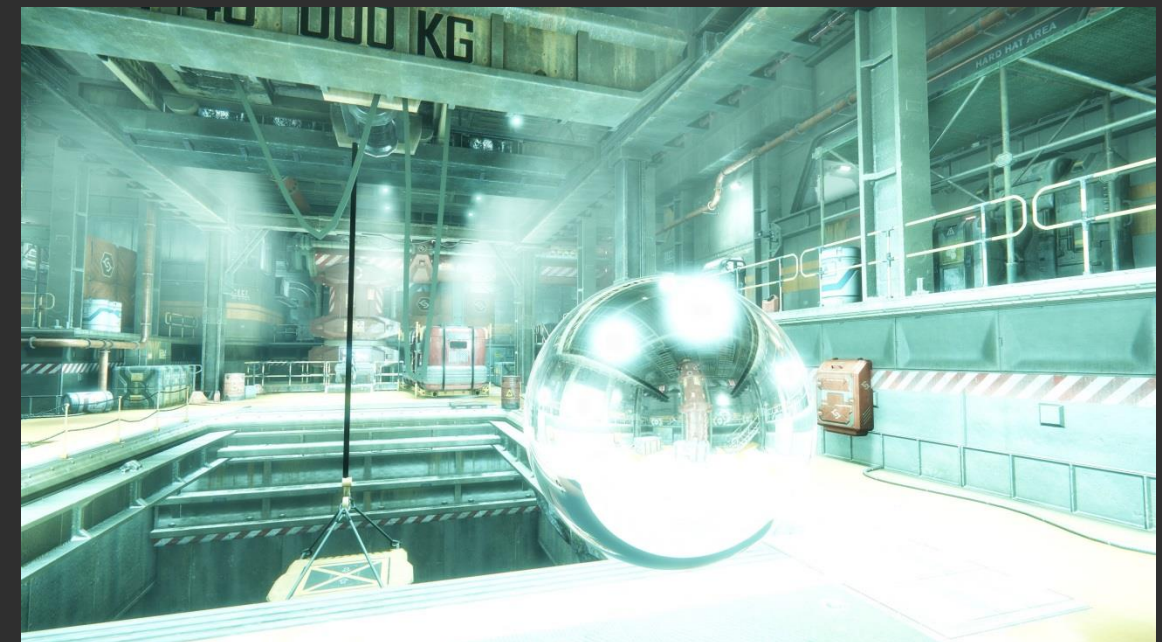
PC/ PS3 : FP16

Xbox 360: FP10

Large range

Many F-stops

Nearly zero banding



Light Entities \Omni Light

Point light

Spherical light volume

Shadow mapping



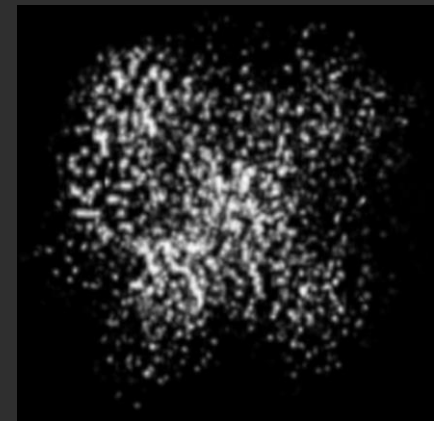
Light Entities \ Projector Light

Point light

Conical light volume

Projection texture

Shadow mapping



Light Entities\Projector Light FOV



Light entities \Area Light

Surface light (rectangle)

Shadow mapping with penumbra approximation

Projection texture (optional)



Narrow light source & sharper shadows



Wide light source & blurrier shadows

Environment probe

Capture of the lighting in an HDR image

Reflections (specular component)

Ambient (diffuse component)

Workflow

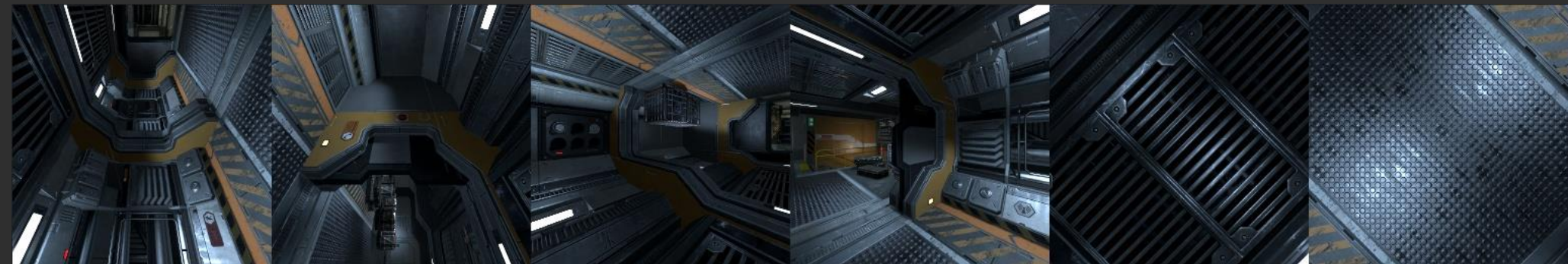
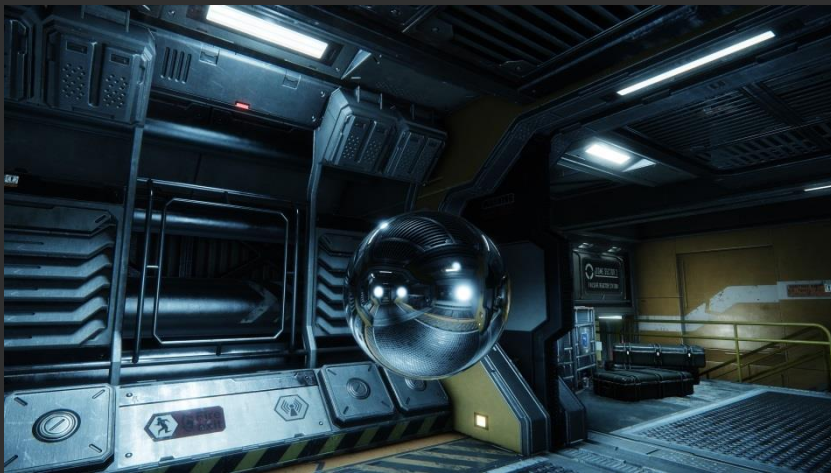
1. Placement of the probe in a key location
 - Center of rooms and outdoor areas
 - Corners and edges of large areas
 - Areas with strong light variations
 - Area with sensitive materials (strong specular luminance & glossiness)
2. In-editor generation of an HDR cubemap texture (6 faces)
3. Rendering using a spherical or parallelepiped volume



Environment Probes\Cubemap



HDR cubemap (tone mapped)



HDR cubemap (tone mapped)

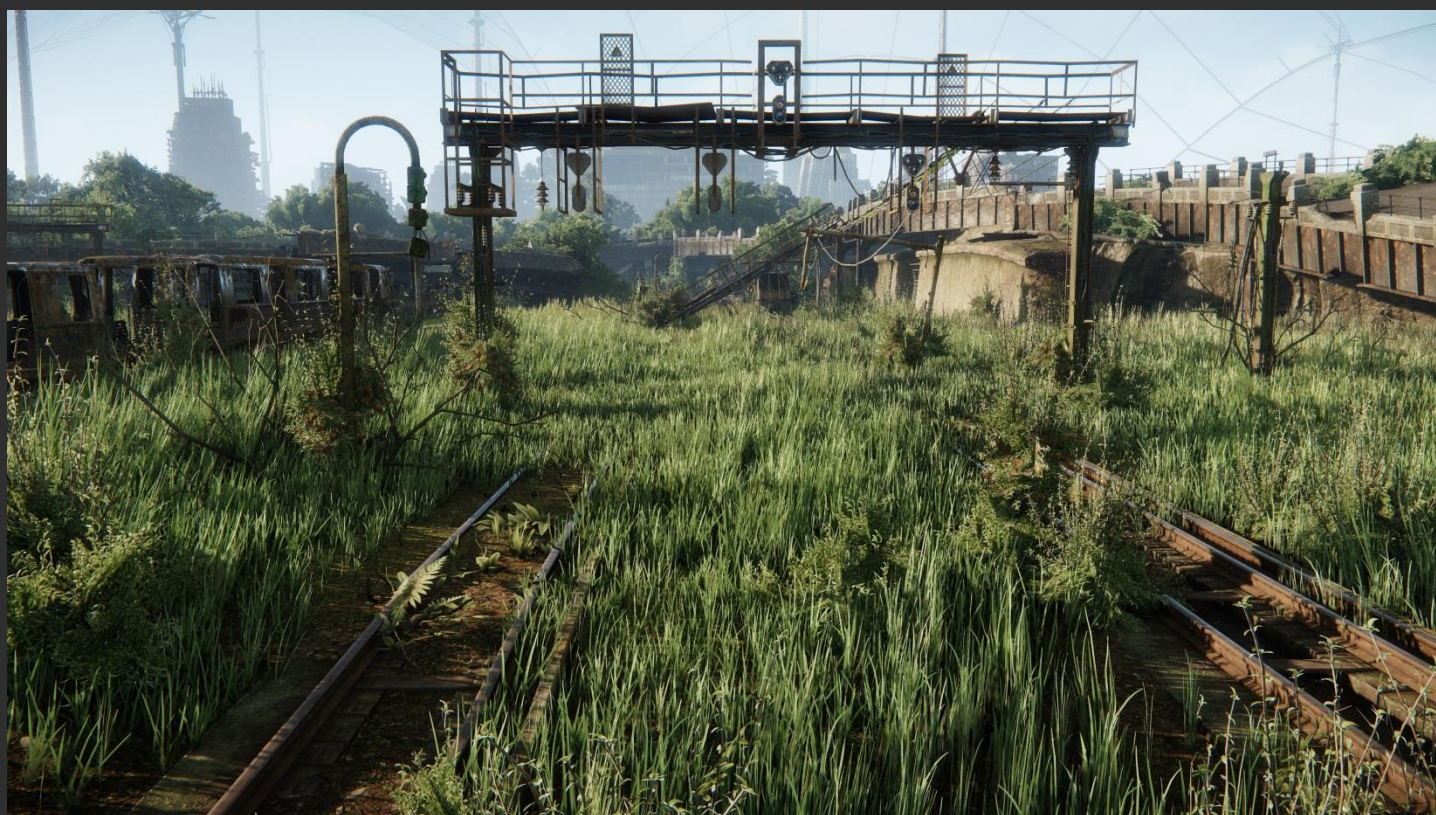
Sun Shadows

Cascades shadowmapping

6 sun cascades

Closer cascades to the camera have higher resolutions

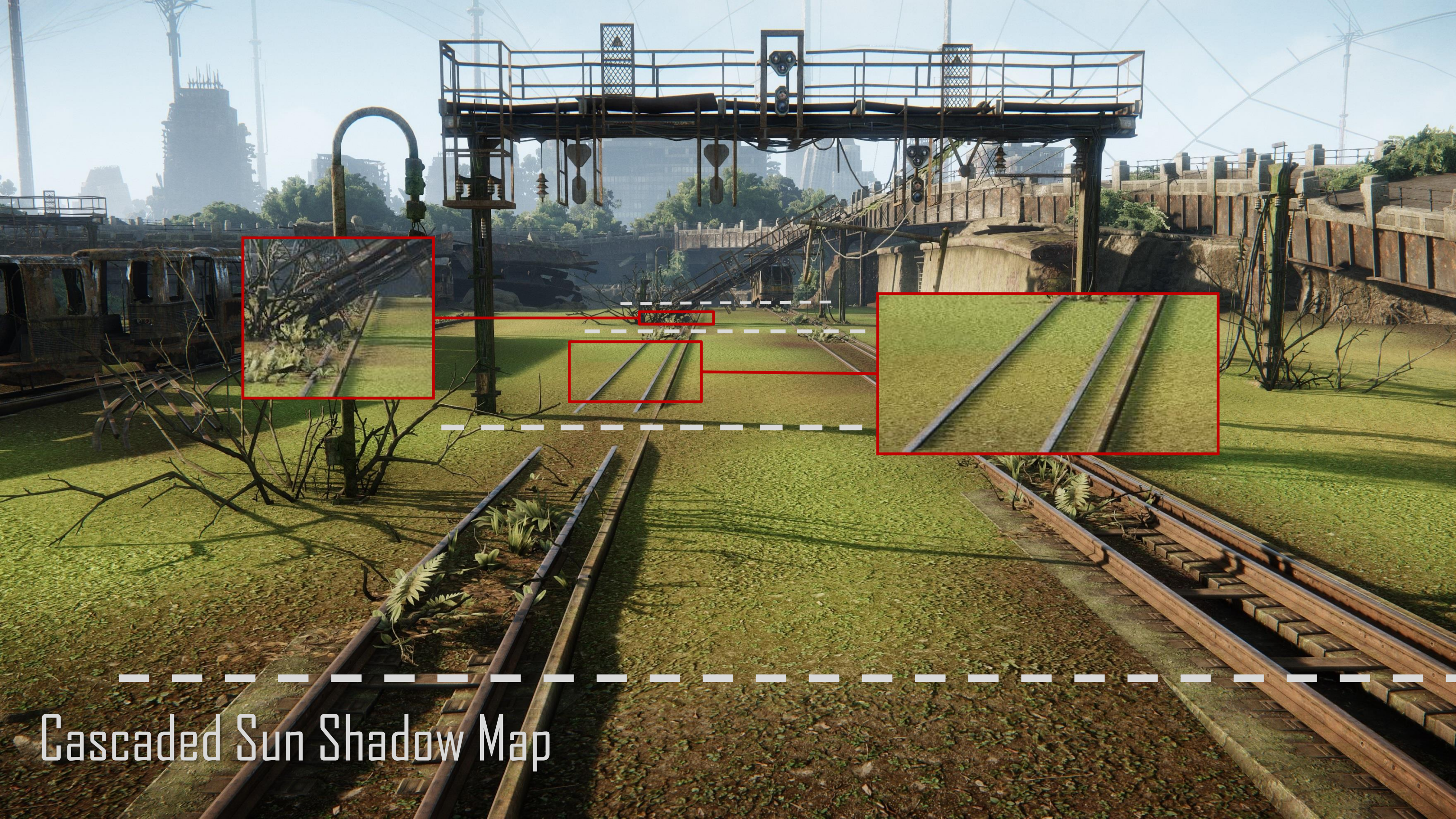
Possible shadow map acne on higher cascades



Vegetation on



Vegetation off



Cascaded Sun Shadow Map

Ambient Occlusion

Simulation of light accessibility

Screen Space Ambient Occlusion

Compute the occlusion amount of "random" pixels on the screen

Developed for Crysis 1 (2007)

Improved for Crysis 2 (2011)

Low performance cost (consoles)

Screen Space Directional Occlusion

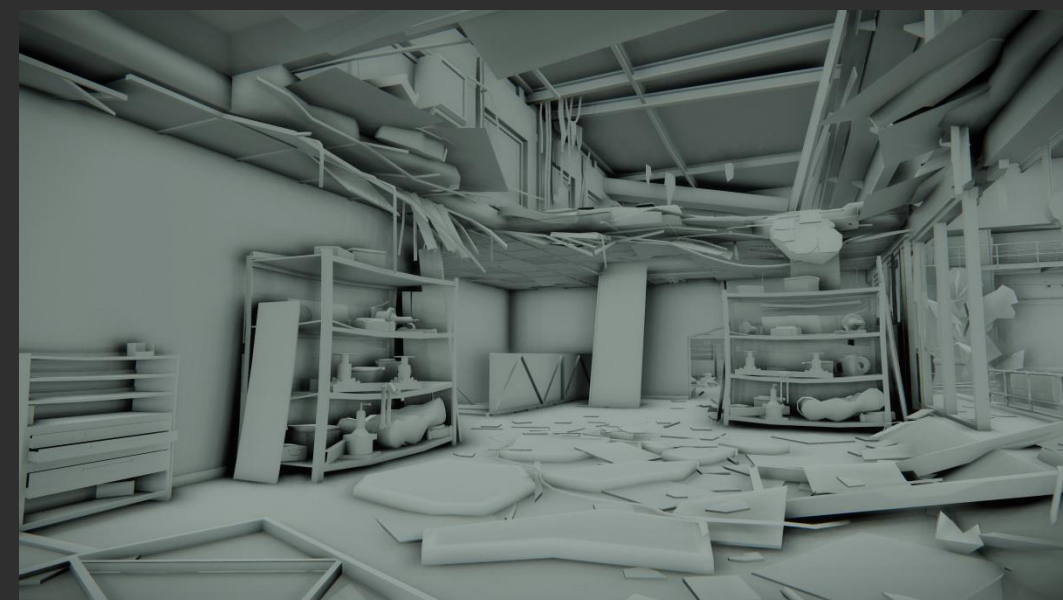
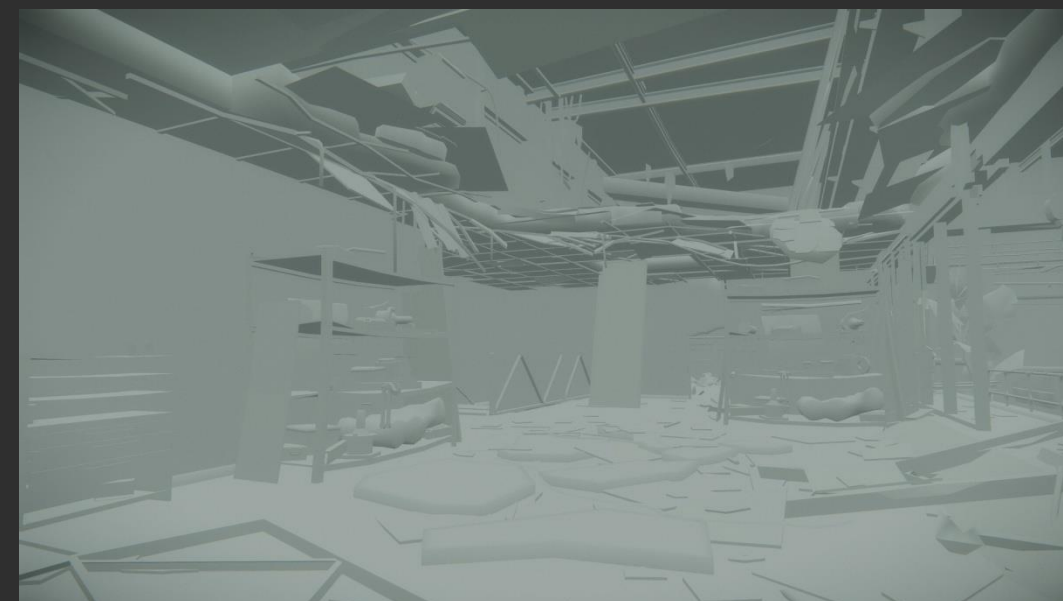
Improved SSAO based on light source direction

Contact shadows

Developed for Crysis 2 DirectX11 upgrade (2011)

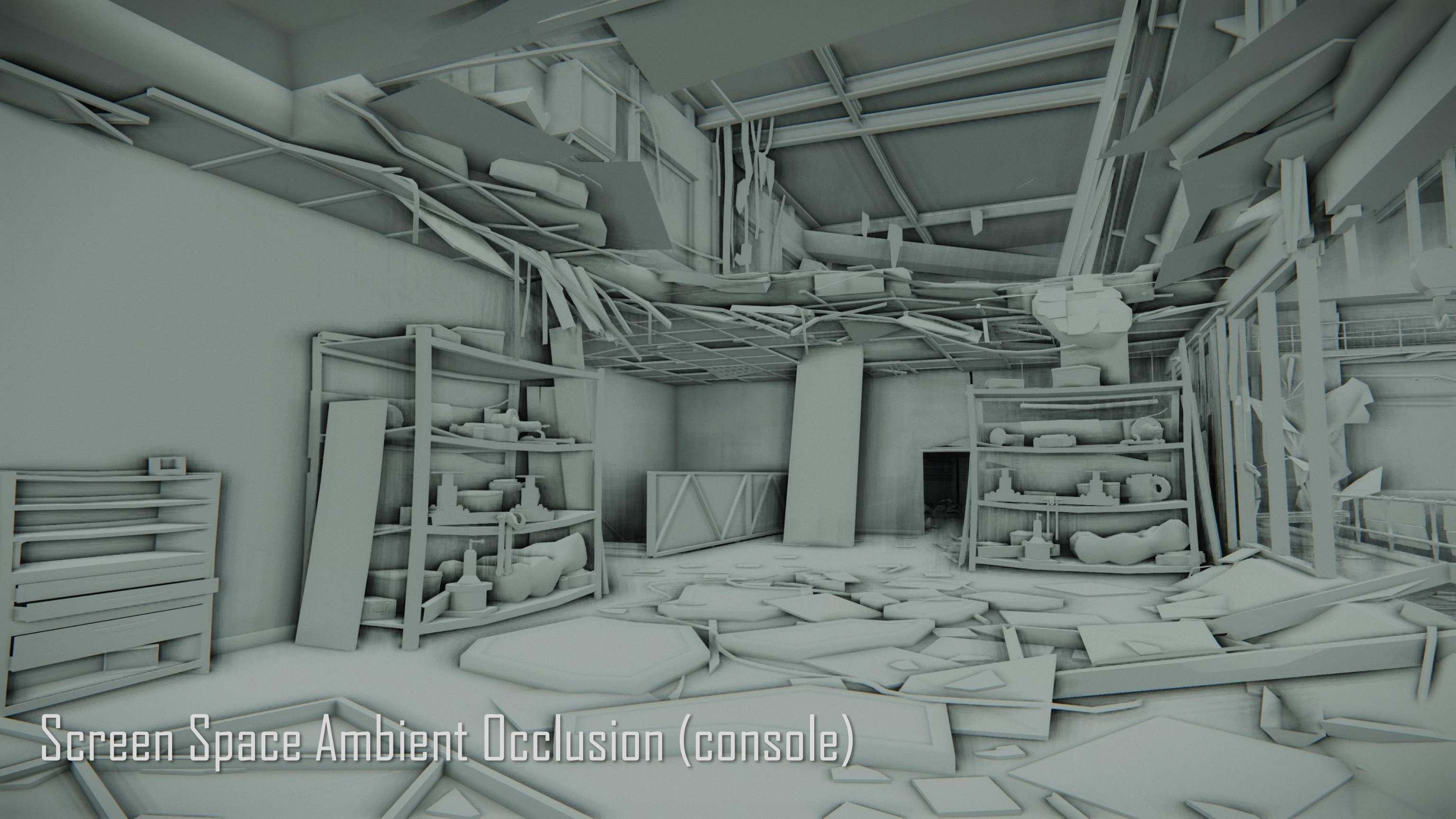
Improved for Crysis 3 (2013)

Higher performance cost but higher quality (PC)

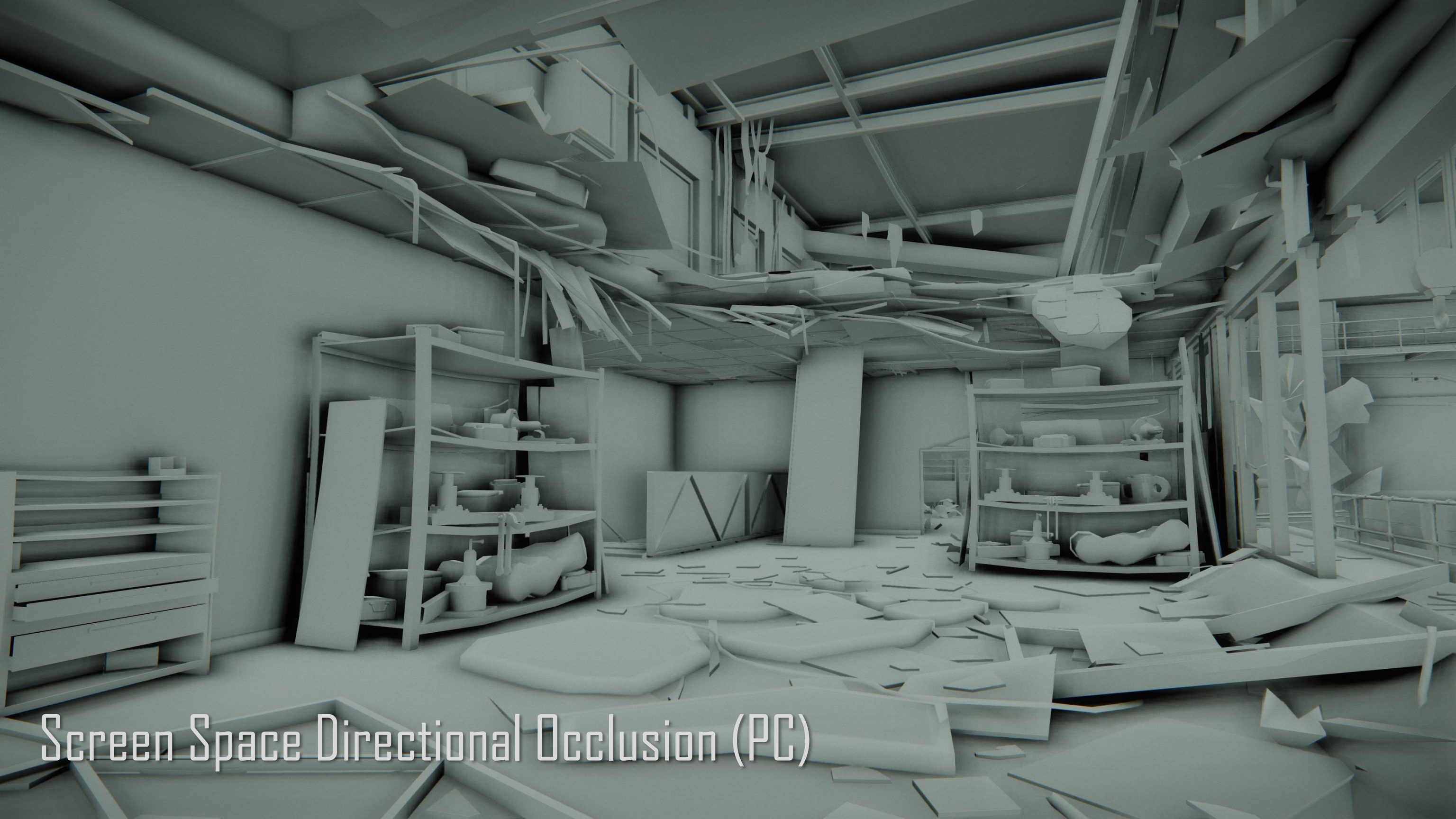




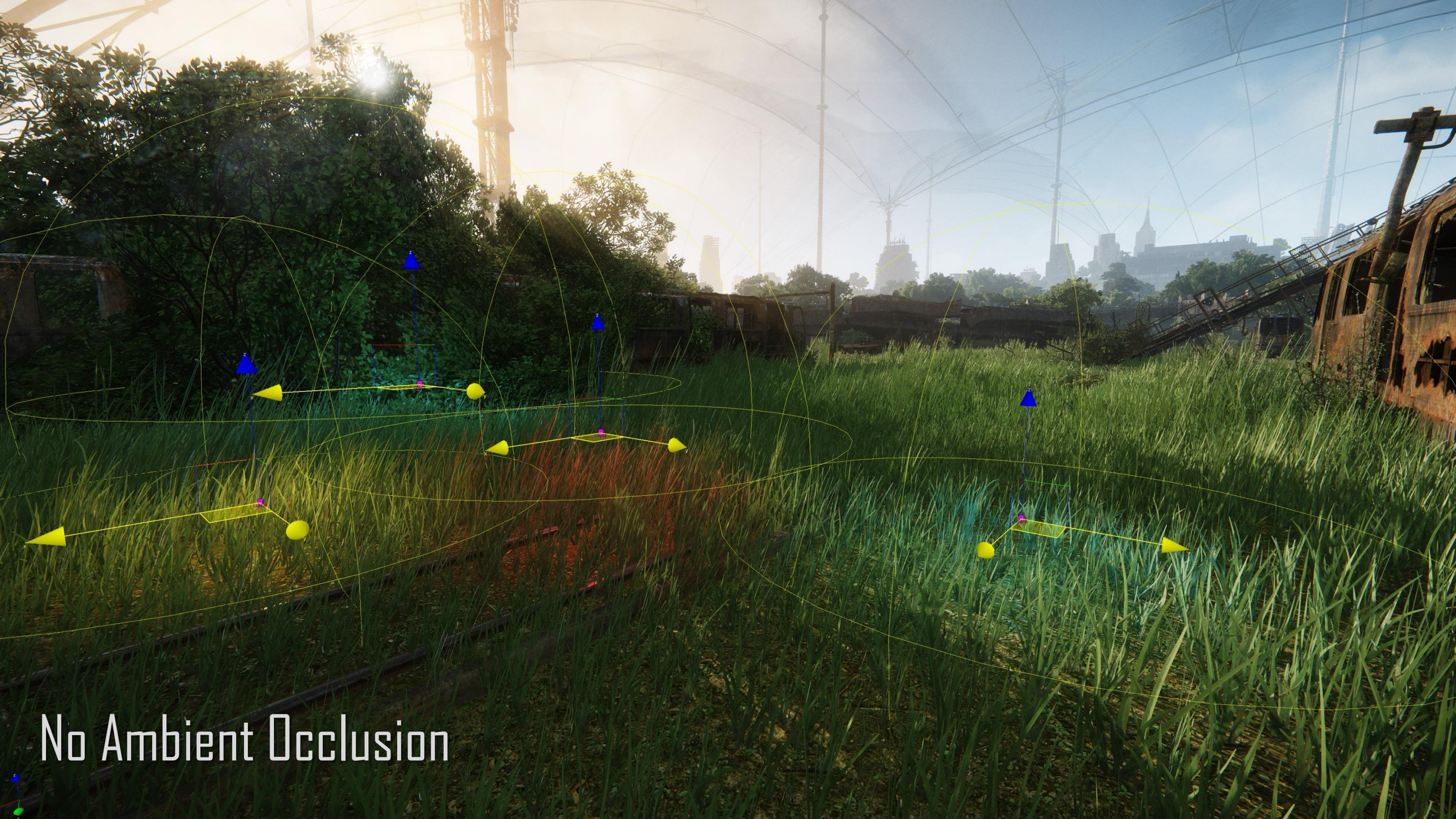
No Ambient Occlusion



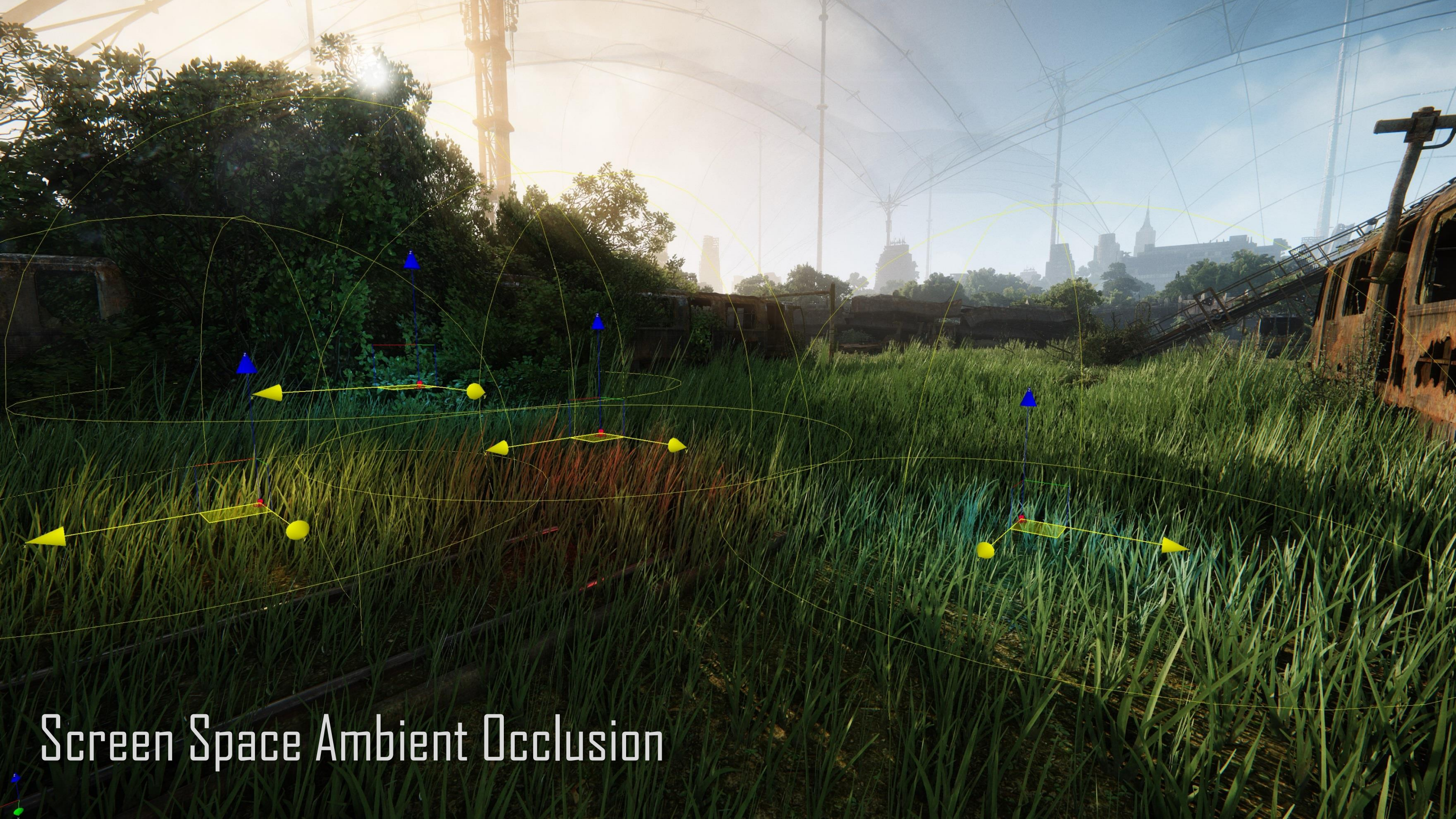
Screen Space Ambient Occlusion (console)



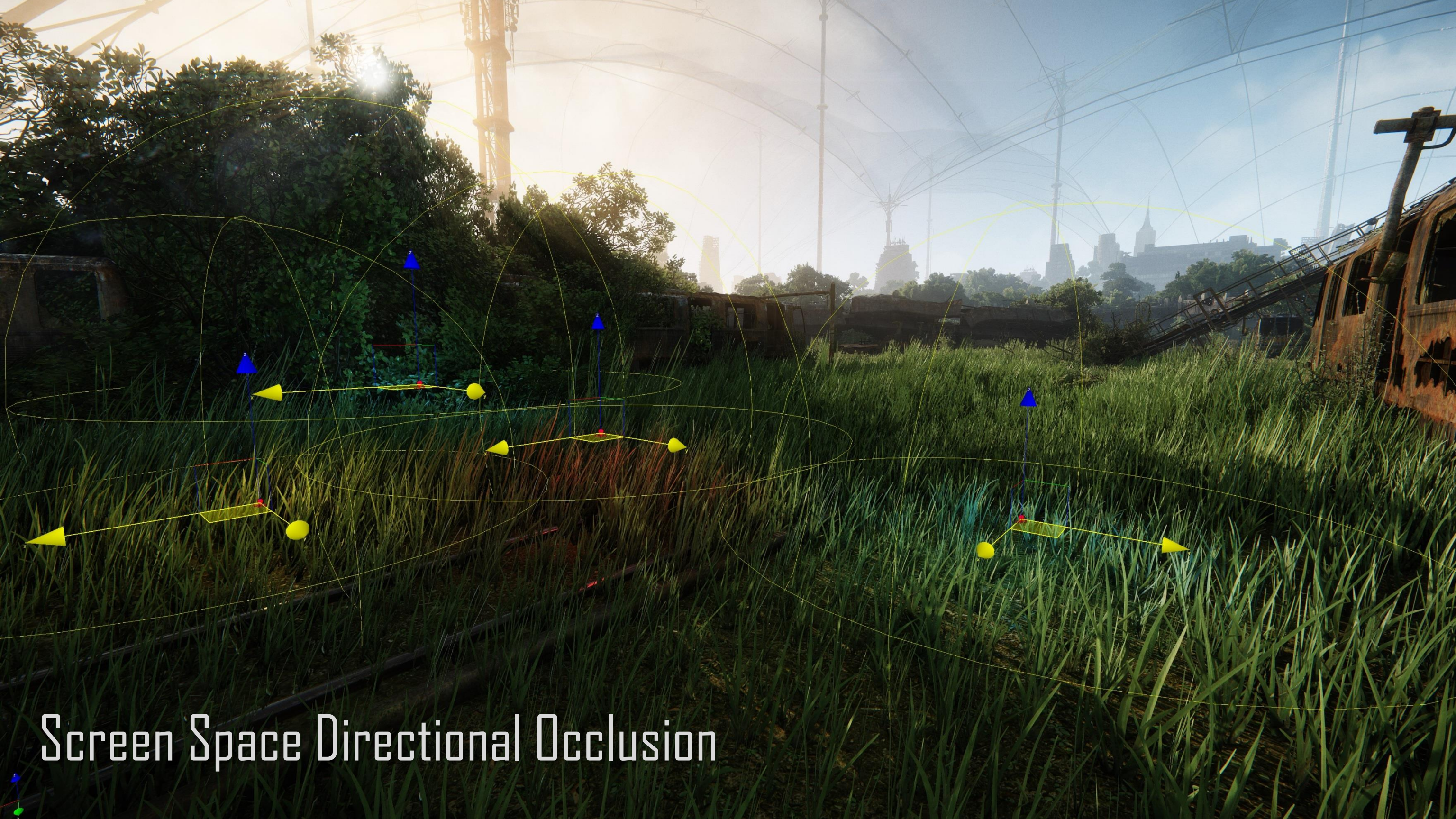
Screen Space Directional Occlusion (PC)



No Ambient Occlusion



Screen Space Ambient Occlusion



Screen Space Directional Occlusion

Ambient Occlusion

Screen space techniques

"Dumb" occlusion

Total ignorance about objects outside the screen or behind the camera

Simulation of light occlusion for micro details (< 2 m)

Macro Ambient Occlusion (> 2 m)

Vertex colors (baked)

Good quality when baking an entire scene

Not recommended in the player area for diffuse consistency

Low flexibility

Darkening lights (dynamic)

Hand-made ambient occlusion

High flexibility

Manual Ambient Occlusion

Subtractive approach

Bright global ambient

Dark local ambient

Negative lights (ambient lights)

Environment probes





Manual Ambient Occlusion



Default Lighting



SSDO



Sun Light



Manual darkening



Global Illumination



Manual Light Bounces

Global Illumination (GI)

Procedural 3D grid of lights

- Every surface considered as a potential light caster

- Sun support only

Pros

- Dynamic GI for outdoor environment

- Decent results in noisy environment

Cons

- Unusable for interior lighting

- Low precision and highly inconsistent

- No automated occlusion (leaking)



No global illumination



Global illumination



Manual bounce lights (helpers)



No global illumination



Global illumination



Manual bounce lights (helpers)

Time of Day

Outdoor lighting tool

Keyframe-based

24 hours cycle

Moving sun

~100 parameters

Sun & sky light

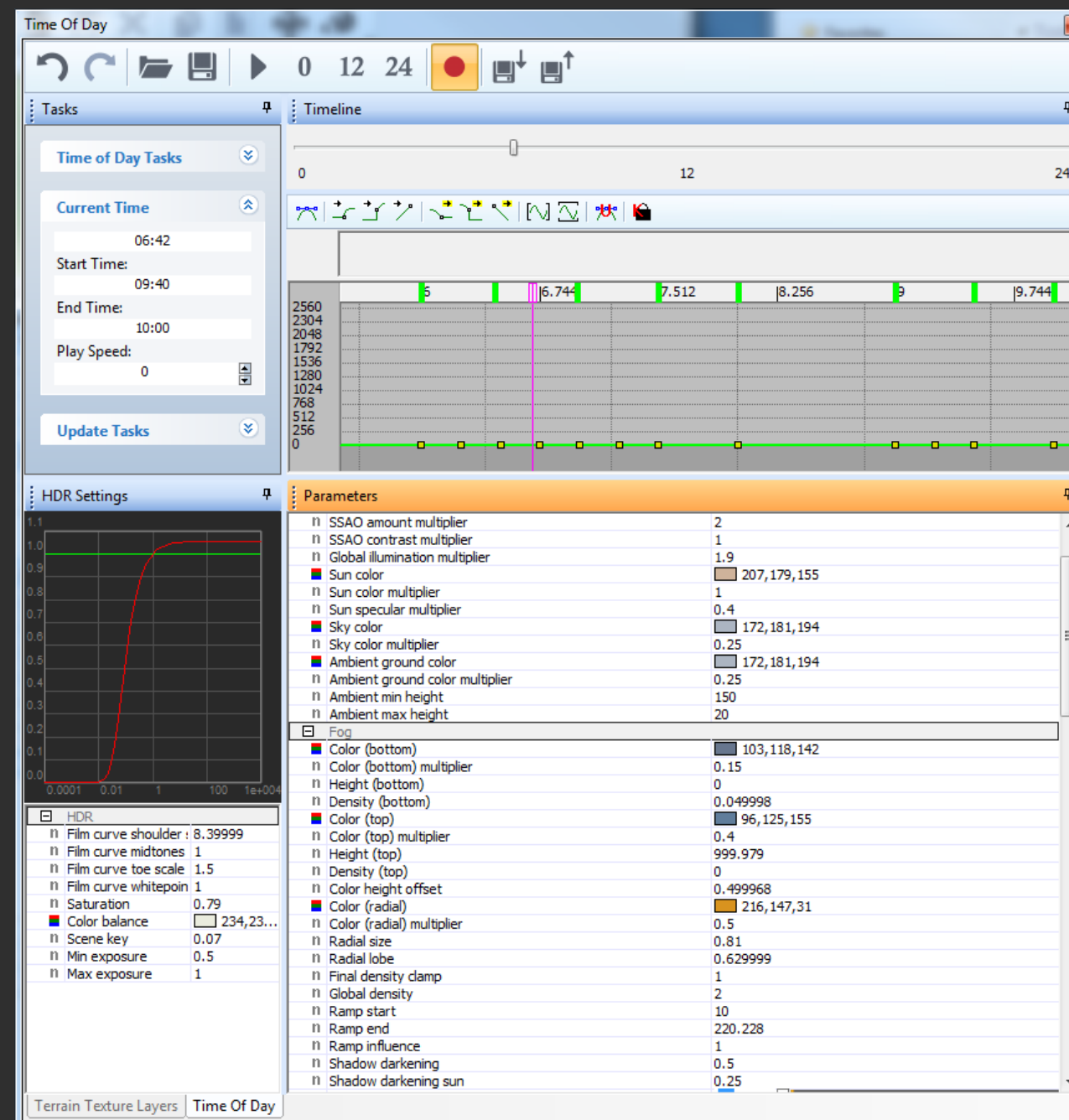
Fog & HDR skybox

Post-processing

Tone mapping & eye adaption

Color balance

Photo filter



Sun position

Crysis 1

- Mix of static and moving sun

- Ideal for semi-open world environment

Crysis 2 & 3

- Scripted sun position

 - Up to 10 static sun positions per level

 - Sun coordinates changed in "streaming tunnels"

- Ideal for contained environments with large scale assets

 - Ensure optimal lighting ratio in every area

 - Prevent areas from being totally in the shade

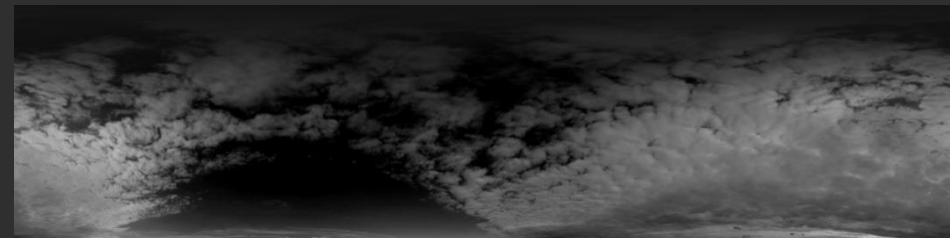
Sky Techniques Evaluation

~~Painted skybox~~

- + More dramatic
- Old school
- Low flexibility
- Difficult authoring
- Often looking fake (shading)

Photo-based hemispheres

- + Best visual result
- + Compatible with procedural skybox
- Sun shading



~~Cloud billboards/decals~~

- + High flexibility for cloud placement
- + Compatible with procedural skybox
- Alpha-blending overhead

Sky System

Technologies

Procedural HDR skybox

Alpha-blended HDR clouds hemispheres

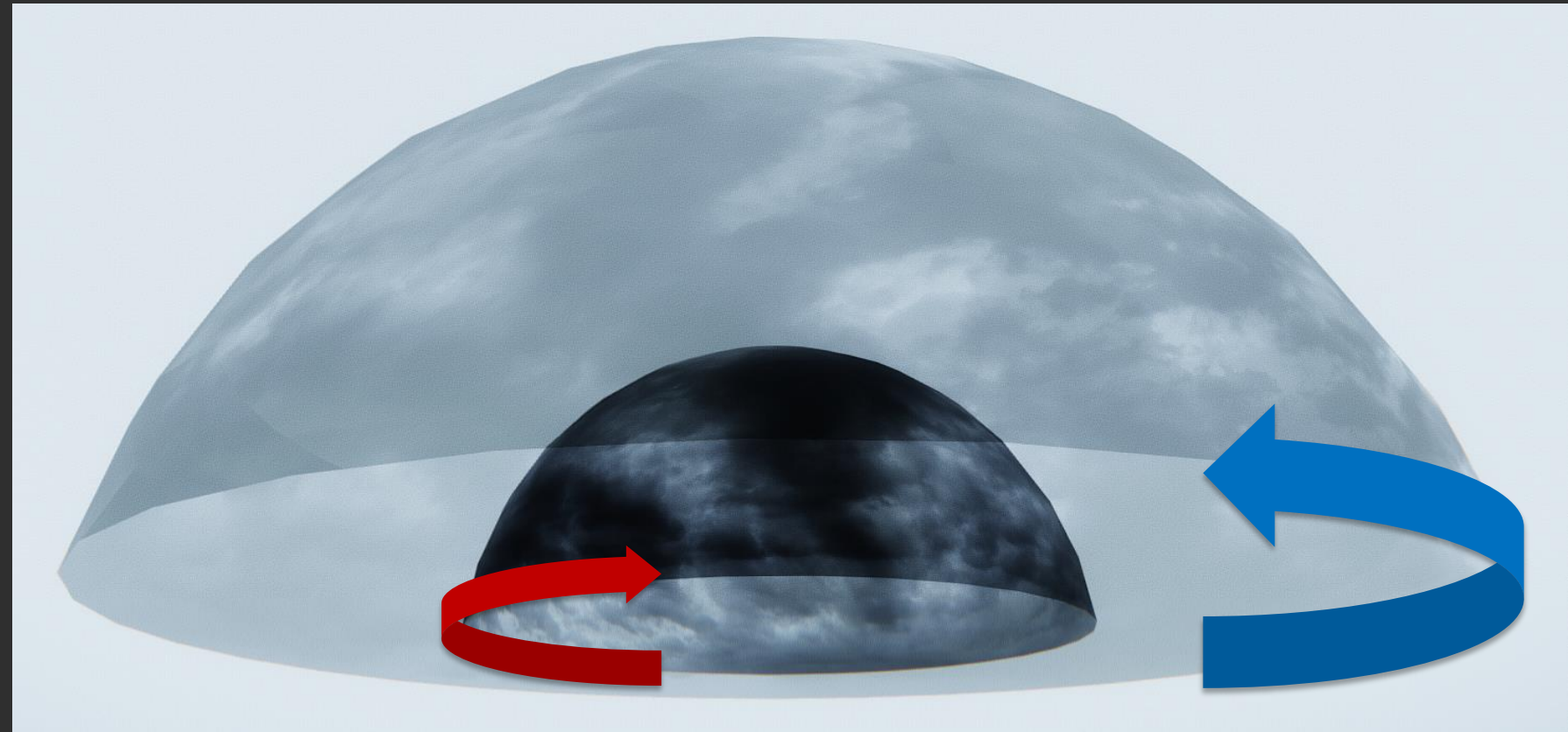
Tileable cloud shadows

Dynamism

Moving clouds

Moving cloud shadows

No more old gen static painted skyboxes!



Sky Domes

Main sky dome

- Detailed clouds

- Limited rotation angle

 - Preservation of sun shading

- Visible on all platforms

Secondary sky dome

- Low opacity mist

- Constant rotation

- Visible on PC only

- Alpha-blending cost



Cloud Shadows

Revived technology from Crysis 1

- Scrolling tileable texture

- High tiling to maximize shadows variation on the ground

- Black clamped to grey to prevent too dark shadows

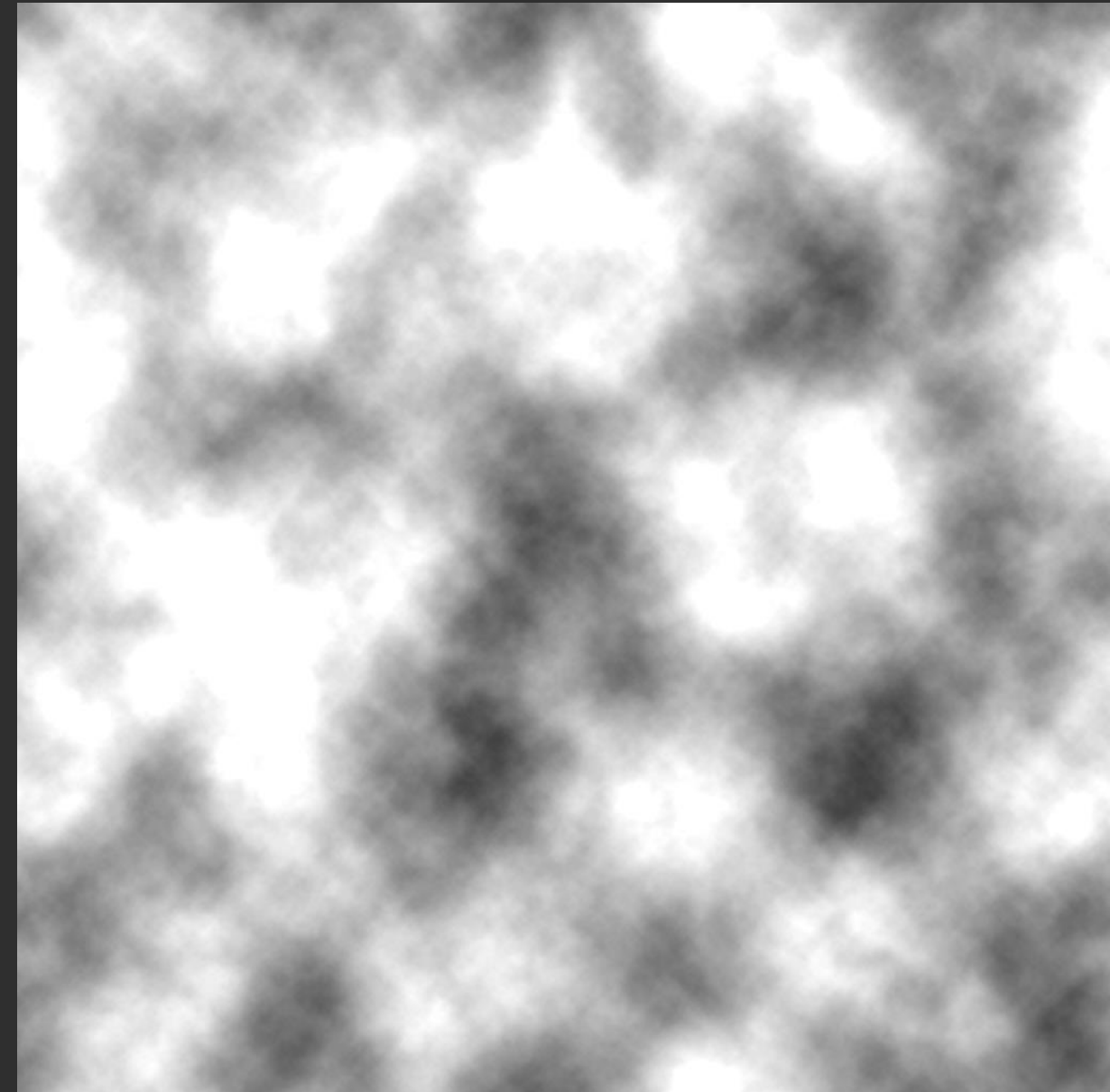
Pros

- Give more life to the environment

- Leading the player in the right direction

Cons

- Inconsistent with the actual clouds hemispheres



Cloud shadow texture

Real-Time Lighting Analysis

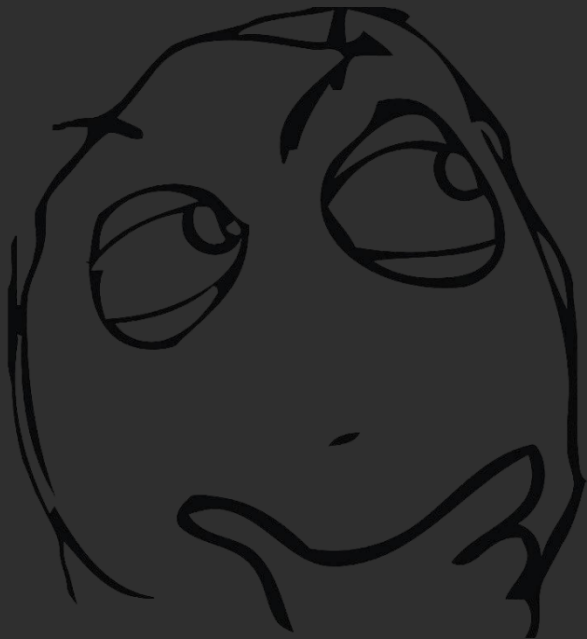
Pros

Very fast lighting rendering times

A few milliseconds per frame only

Instant visualization of the final results

Moving and dynamic lighting



Cons

Strong limitation for low end platforms

Amount of lights

Radius

Shadow casting

Overlapping

Waste of resources on non-dynamic scenes

Static sun lighting

Static interior lighting

Huge amount of manual work

Time-consuming interior lighting

Manual light bounces

Manual light occlusion

Case study

Outdoor Lighting

Canyon Case Study

Deep canyon

Dark & cold

Dappled lighting

Light beams

Technique used

Light subtraction

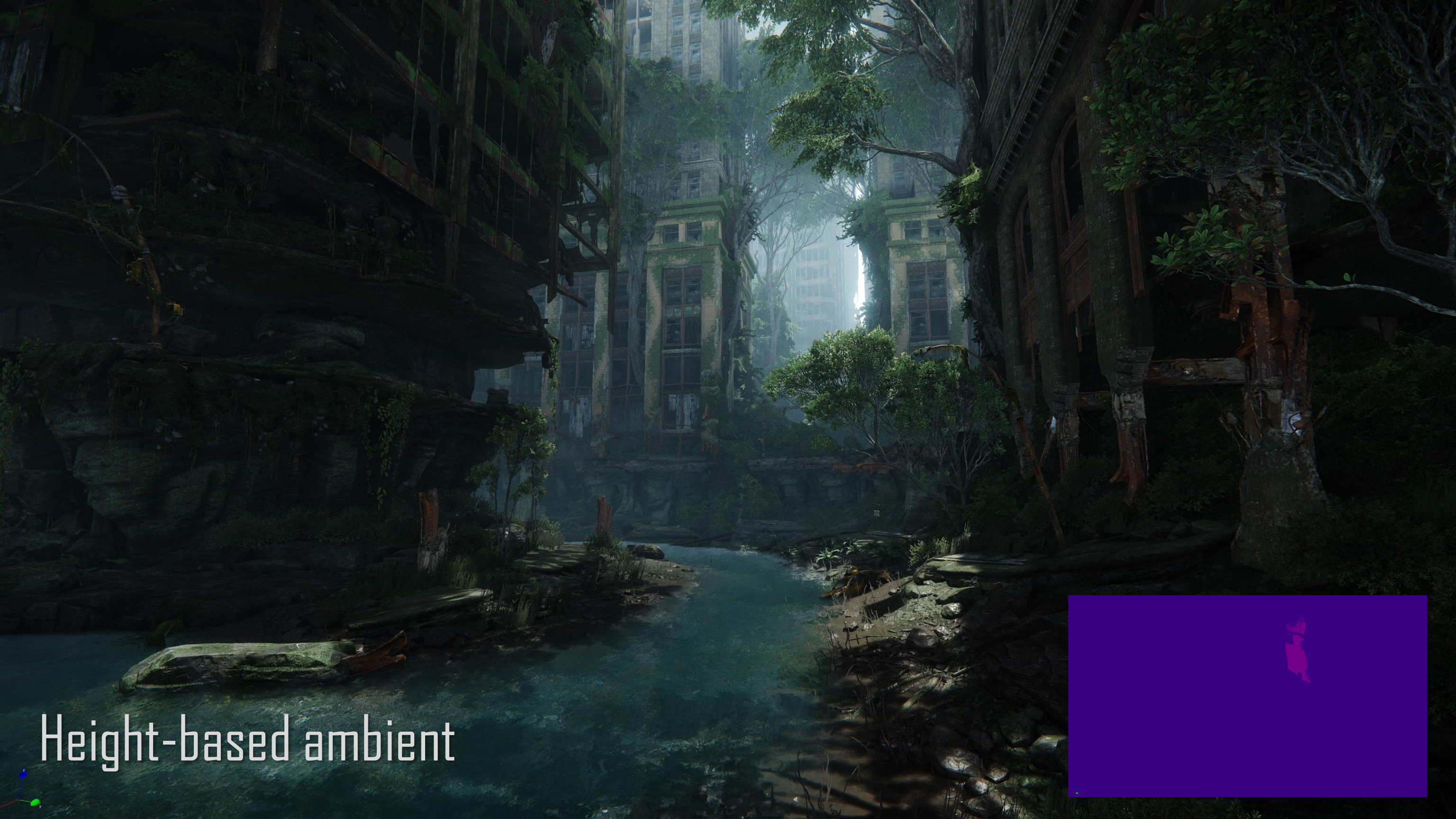




Flat lighting



SSDO



Height-based ambient





Darkening (helpers)

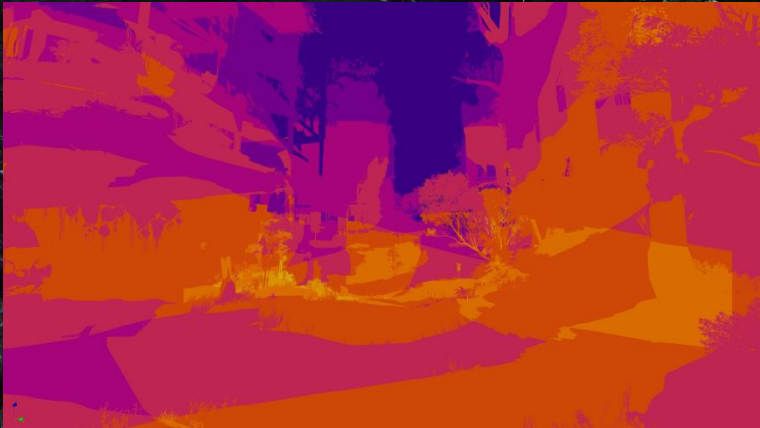




Wet lights (helpers)

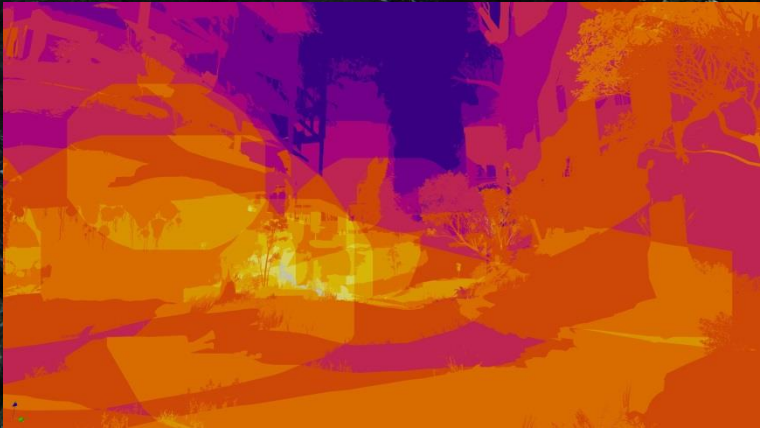


Dappled lighting (helpers)





Light bounces (helpers)





Global environment probe

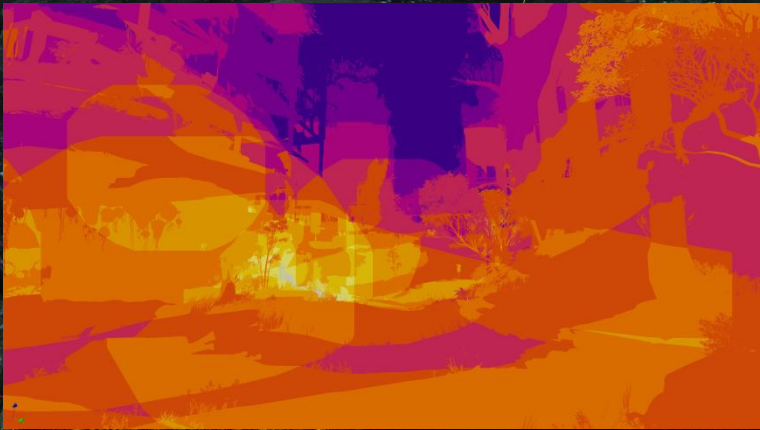




Light shafts (helpers)



Final (PC) (helpers)





Final (PC)



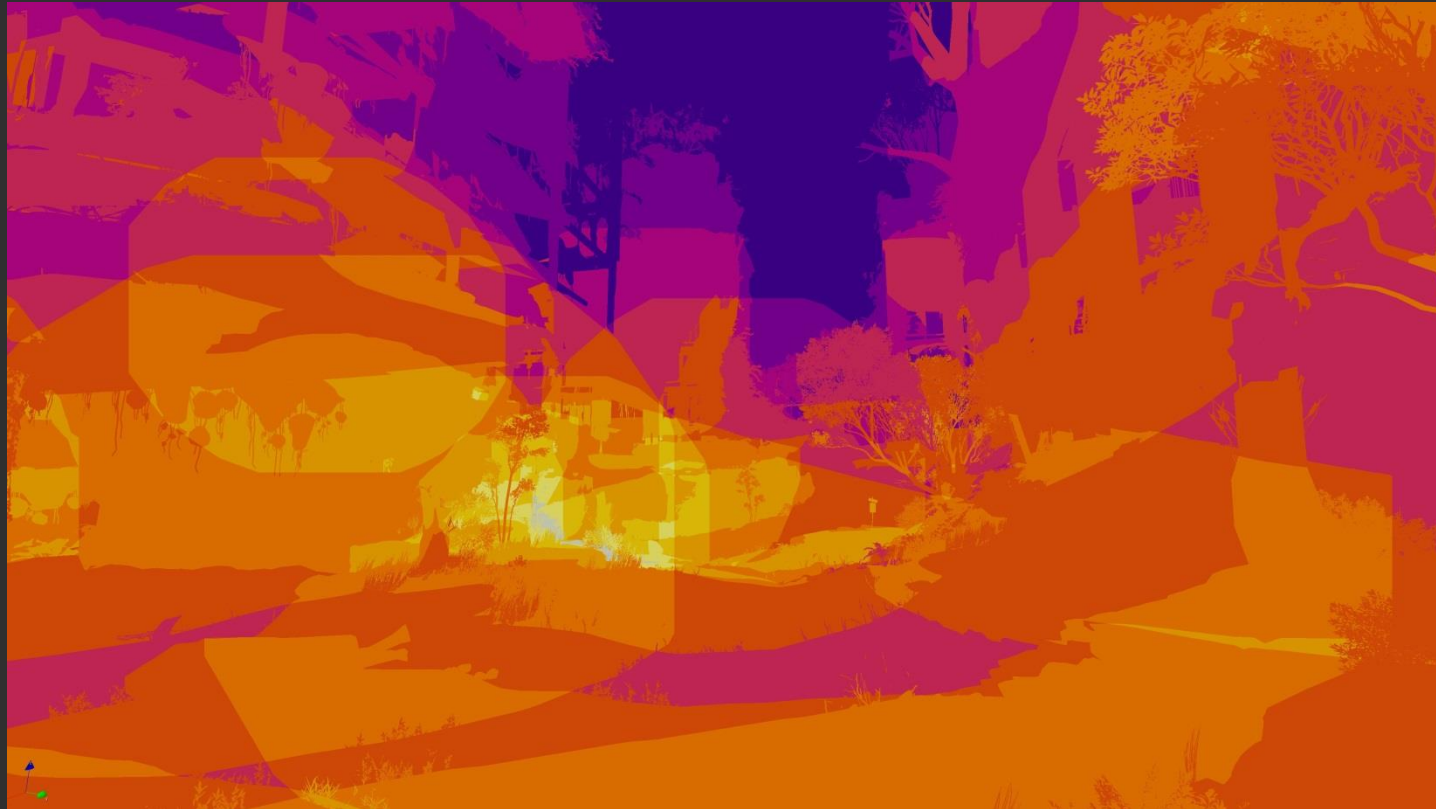


Final (console spec)

Canyon Case Study

PC (670 GTX)

60 lights @ 2 ms



Console

20 lights @ 6 ms



Case study

Indoor Lighting

Interior Case Study

Additive approach

- Dark global ambient

- Addition of lights & probes

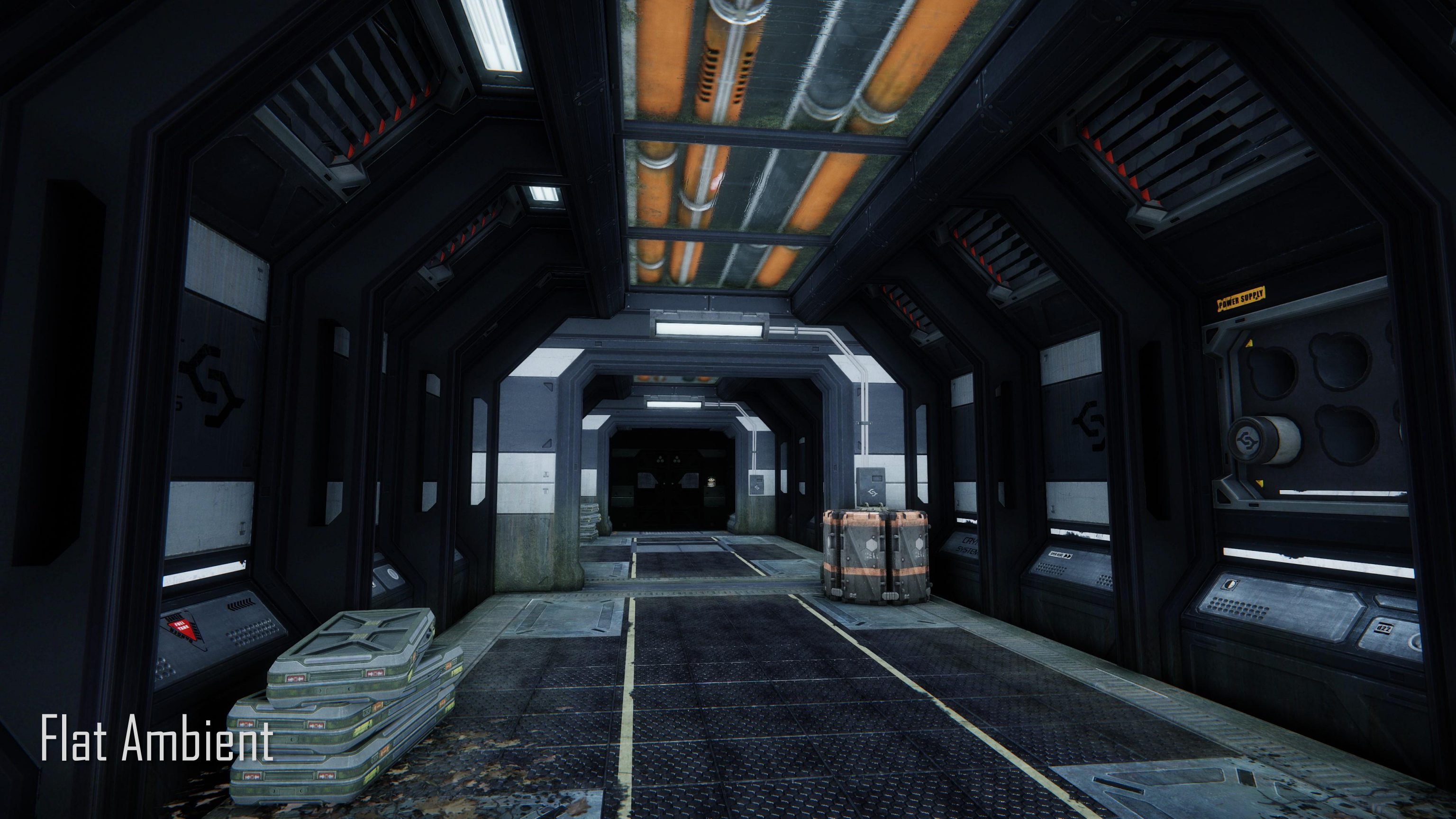
Intensive usage of lighting modules (prefabs)

- Copy by reference (instancing)

- Light a large interior only with a few prefabs



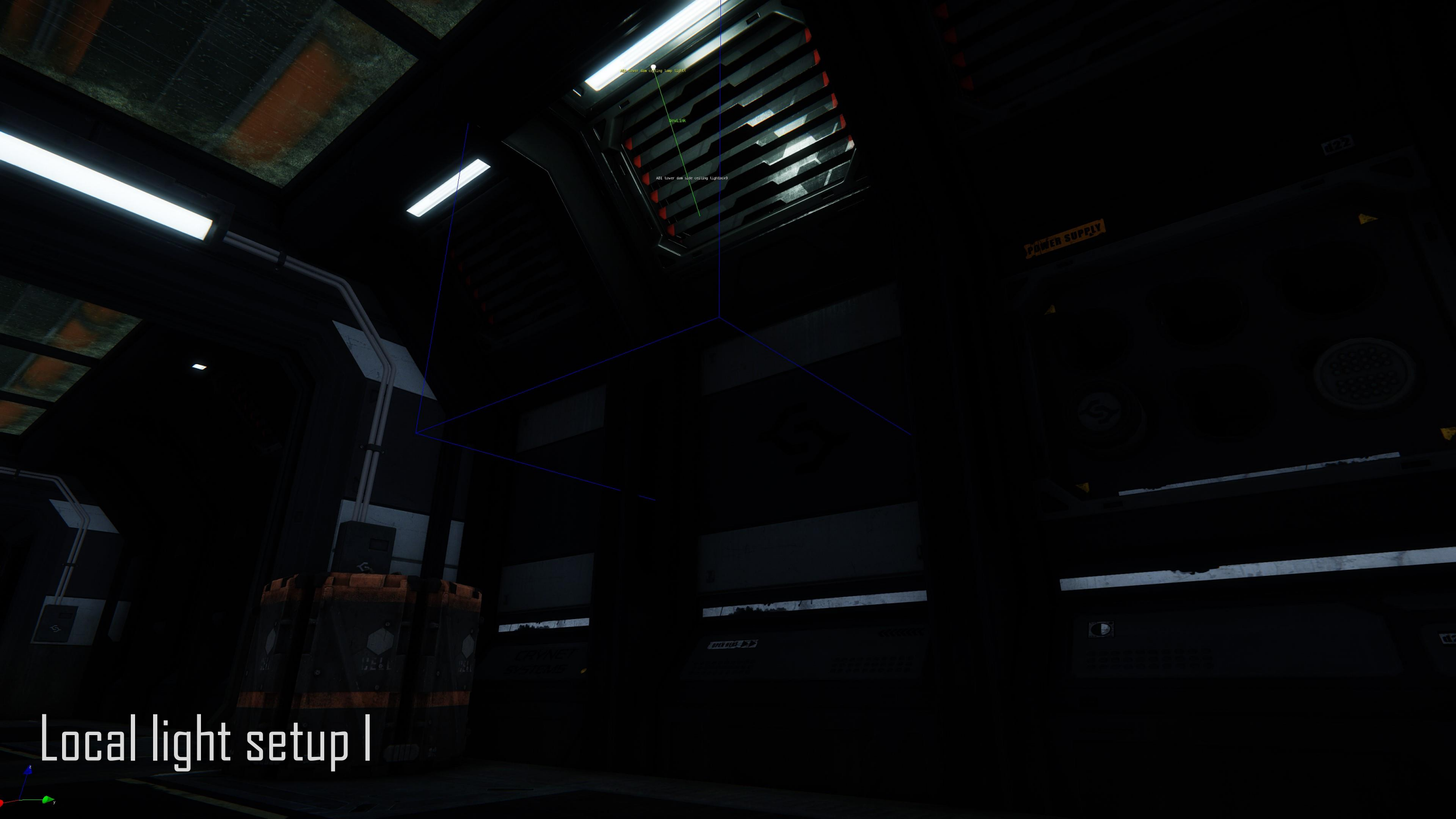
Final



Flat Ambient



Darkening



AD1 lower dom ceiling lamp light03

newLink

AD1 lower dom side ceiling lightbox0

POWER SUPPLY

122

Local light setup I



AB1 lower dom ceiling lamp projective light1
AB1 lower dom ceiling lamp fluxion

AB1 lower dom ceiling lamp light0

newLink

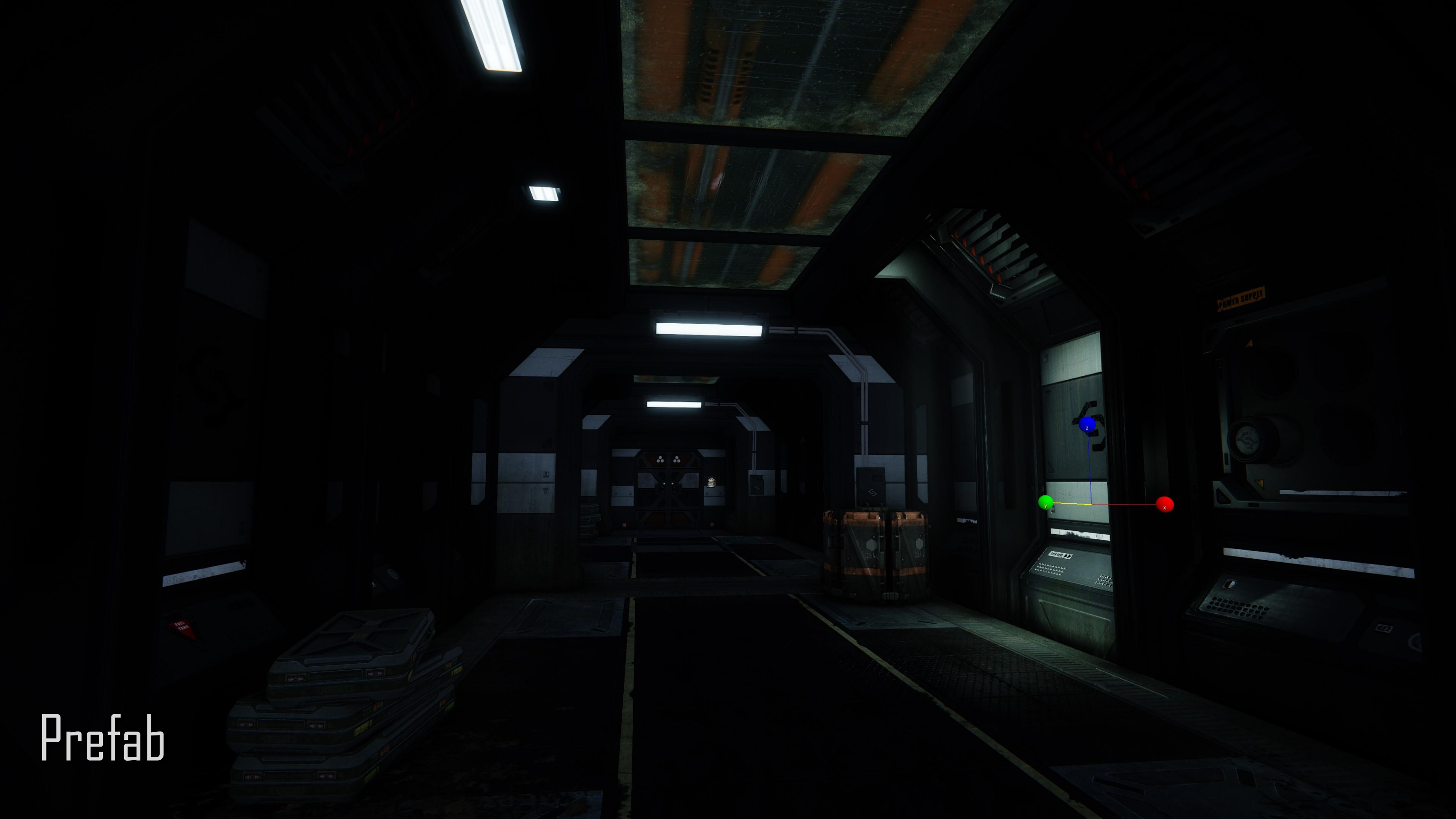
AB1 lower dom side ceiling lightbox0

AB1 lower dom ceiling lamp ambient light 2

Local light setup II



Prefab creation



Prefab



Prefab duplication (instancing)



Prefab editing



Prefab editing

AB1 lower dm ceiling side circular lightshaft1

AB1 lower dm ceiling side projector light1

AB1 lower dm ceiling side projector light2

AB1 lower dm ceiling lamp light1

AB1 lower dm ceiling lamp light2

AB1 lower dm ceiling lamp light3

AB1 lower dm ceiling lamp light4

AB1 lower dm floor side projector light1

AB1 lower dm floor side projector light2



Reference materials



Local probe



Final (PC)

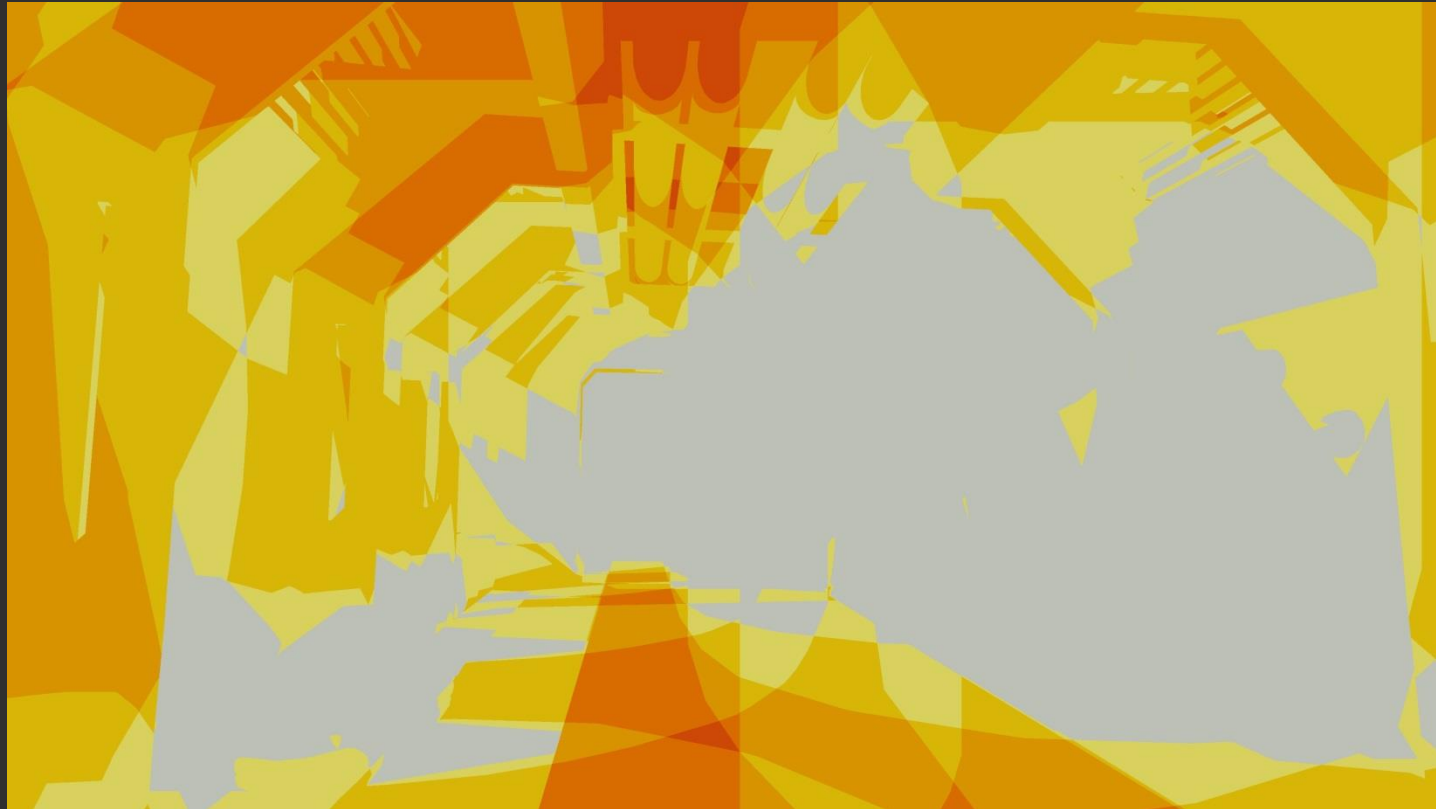


Final (console spec)

Interior Case Study

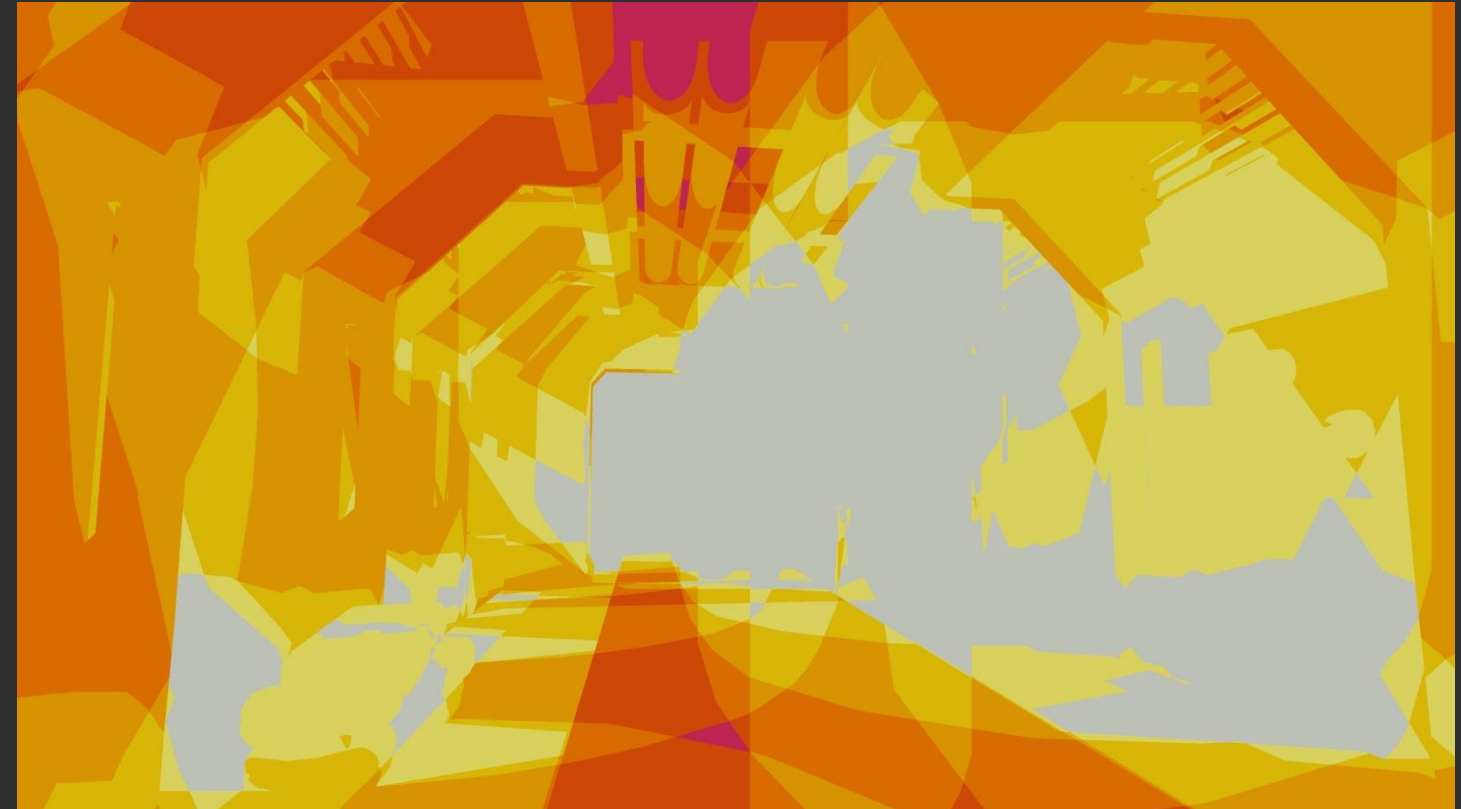
PC (670 GTX)

150 lights @ 4 ms



Console

90 lights @ 10 ms



Case study

Cinematics

Cinematic in Crysis

First person perspective only

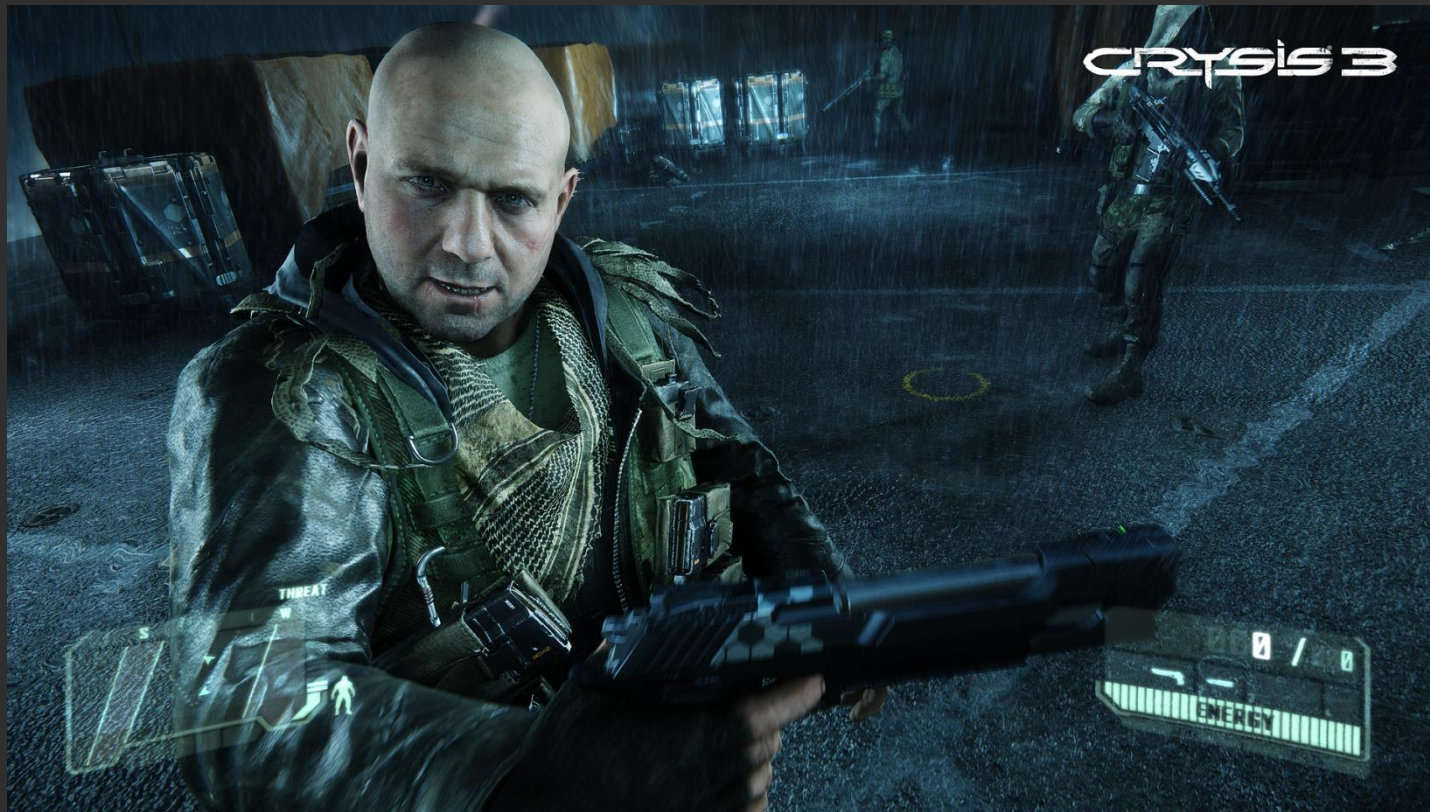
Very limited player camera control

Long takes only

Harder to hide lighting tricks

Off-screen lights

Depth helpers



Character Cinematic Lighting

Main Focuses

- Ensure characters emotions visibility
- Ensure proper skin shading
- Separate characters from the background

3 point lights setup for faces

- Key light
- Fill light(s)
- Back light

Face lights attached to characters

- Torso or head joint





Psycho

CRYISIS 3

CRYSIS 3

Claire



CRYSIS 3



Rash



3 point lights setup



3 point lights setup problems



No character lighting



Key light



Back light



Fill light 1



Fill light 2



No character lighting



Back light



Fill light



Key light



Fill light



Back light



Key light



Back light (sun)



Key light



Fill light

Conclusion

Lighting Statistics

8 levels

54.55% shadow casting lights (PC)

14'716 lighting entities

224 probes

5140 omni lights

2043 prefabs

3063 projector lights

604 light clipping volumes

Next Gen Lighting

More physically-based pipelines

High quality lighting approximation in real-time

Large scale ambient occlusion in real-time

True volumetric effects

...

Special Thanks

Tiago Sousa, Principal Graphics Engineer

Carsten Wenzel, Technical Director

Magnus Larbrant, Senior Art Director

Entire Crytek team

We are hiring!

<http://www.crytek.com/career>

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